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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Three 12in. Centrifugal Salvage Pumps by W. H. Allen Son & Co. Ltd. (Submersible type),
Lindsay, Swan & Hunter (Non-submersible type),
Drysdale & Co. (Non-submersible type).
Five 6in. ditto ditto by Drysdale & Co. with gear boxes and equipments.

STEAM DRIVEN PLANT AT FALMOUTH.
(All by Drysdale & Co.).
Two 12 in. Horizontal centrifugal pumping sets.
One 6in. Vertical ditto ditto
Two 4in. ditto ditto ditto
Complete with gear boxes and equipment.
One COMPLETE SUBMERSIBLE SALVAGE UNIT, consisting of OIL ENGINE, direct coupled to ALTERNATOR AIR COMPRESSOR, interchangeable with alternator.
AIR RECEIVER.
Two 6in. SUBMERSIBLE PUMPS, and full equipments.

OIL DRIVEN PLANT AT IMMINGHAM.
Two 6in. PORTABLE SALVAGE PUMPS by Drysdale & Co., with gear box and equipment.

Tenders to be lodged by Ten a.m. on 3rd September, 1919, and may be for the above plant as a whole or in part.

Detailed list, together with tender form, and permits to view, can be obtained from the CONTROLLER, D.B.1. (e), Charing Cross Embankment Buildings, London, W.C. 2. X 659

OTAGO HARBOUR BOARD,
NEW ZEALAND.

BOILER FOR TUG.

The Otago Harbours Board, Dunedin, New Zealand, invites

Tenders for a Boiler or Boilers

of any suitable description for the Tug "Dunedin."

Firms desiring to submit Tenders may inspect plans at the office of, and obtain copies of the Specification and Conditions from the High Commissioner for the Dominion of New Zealand, London.

Tenders, enclosed in a sealed envelope (registered), endorsed "Tender for Contract No. 468," and addressed to the Chairman of the Board, will be received at Dunedin up till Noon on Tuesday, January 13th, 1920.

The lowest or any Tender not necessarily accepted.
W. J. BARDSLEY,
Secretary.

Otago Harbour Board,
Dunedin, N.Z.,
11th June, 1919. X 773

GRIMSBY CORPORATION ELECTRICITY DEPARTMENT.

SPECIFICATION No. 140.

The Corporation are prepared to receive

Tenders for the Following:—

SPECIFICATION No. 140.
Part I. COAL AND ASH HANDLING PLANT.
Part II. 30 TON TURBINE HOUSE ELECTRICALLY-DRIVEN TRAVELLING CRANE.

Part I. includes Overhead Runway with Electrically driven Traveller; Coal Elevators, Ash Trucks, &c.

The parts may be tendered for independently.

Specifications and Drawings may be obtained from the Undersigned on payment of a deposit of One Guinea, which will be returned on receipt of a *bona fide* Tender.

Tenders are to be received by first post, Thursday September 25th.

Corporation Electricity Works,
Grimsby.
August, 1919. X 803

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering.

University of Bristol.—Assis-

TANT LECTURER IN MECHANICAL ENGINEERING. £250–£10–£300.—For particulars send stamped, addressed, foolscap envelope to the REGISTRAR, Merchant Venturers' Technical College, Bristol. X 686

EDUCATION FOR MANAGEMENT.

By HUGH P. VOWLES, A.M.I.Mech.E.

THIS article is written primarily from the point of view of an engineering works manager, but it will be apparent that the line of thought followed is equally applicable to management in many other spheres of activity. It is not intended to discuss the merits of technical education—a subject which has already been dealt with elsewhere by other and abler writers—nor yet to indicate, except by way of illustration, the specific problems that a manager is called upon to solve. It is to another, and too often neglected, aspect of management that attention will be drawn. Briefly, the intention is to maintain and illustrate the following truth:

That whereas the functions of a manager can be divided into (*a*) relationships with matter and energy, and (*b*) relationships with mind and human action; and whereas during recent decades we have been driven to realise that mere "rule of thumb" based on personal experience is inadequate in the case of (*a*) unless accompanied by a knowledge of physical science, so must we now realise in the case of (*b*) that personal experience and native ability are inadequate when not amplified and invigorated by a knowledge of social science, or sociology, the science of human interaction.

It will further be maintained that with every step forward in working class education, such knowledge becomes of more and more importance to the manager. Indeed, it is submitted that ability to understand and cope with human relationships is already to-day more important than—though only too often lagging far behind—high technical qualifications in a managing engineer.

Sociology, in the widest sense of the term, covers a number of sciences passing far beyond the scope of the average works manager. His range, *qua* manager, is narrowed down to the industrial aspect; and ignorance of—let us say—eugenics will not lessen his efficiency as a manager more than ignorance of radio-activity would lessen his efficiency as an engineer. But once it is admitted that some education in physical science is necessary to the engineer, it can scarcely be denied that a study of sociology is essential to the manager. Indeed, the modern manager already recognises the advantages of studying the "mechanics" of human association. He will read such books as Taylor's "Scientific Management," or Elbourne's "Factory Administration," which deal with human association so far as this can be done by practically ignoring human idiosyncracies. There are advertisement managers who have also familiarised themselves with works on crowd psychology, and attempt to apply the ideas of le Bon, Munsterberg and William James to their profession. But for reasons that will appear presently, the results only serve in many cases to illustrate the old saying, that a little knowledge is a dangerous thing.

Now we all of us, although perhaps unwittingly, are students of sociology from our youth up; and our knowledge is derived from three main sources, viz.:—(1) school; (2) experience; (3) study and reading; and it will be convenient to consider here the comparative value of these three sources of knowledge.

School.—It would be beyond the scope of this article to discuss in detail the advantages and defects of the modern scholastic education. It cannot be seriously disputed, however, that the school boy too often emerges hopelessly ignorant in regard to the everyday affairs of life—receiving many a rude shock when he is subsequently pitchforked into the business world—or that his general trend of thought is inconclusive, lacking that orientation of ideas which would assist him in the acquisition of further knowledge. Nevertheless a modern school education is useful in so far as it does provide some foundation for further knowledge, helps to mould character in the direction of self-reliance, develops poise and a sense of fair play, and encourages determination in the face of difficulties. It is, on the other hand, positively harmful so far as it fosters snobbish tattlessness and aggressive egotism.

Experience.—A considerable amplification of knowledge can be reasonably expected from this source, but it by no means necessarily supplies the cardinal requirement of unification or—as we have already termed it—orientation. Its chief function would seem rather to bring a measure of wisdom to the application of the knowledge the student may now or hereafter possess. Generally speaking, experience is valuable in its operation on a flexible mind if it teaches the student to (*a*) put himself in the place of others; (*b*) see himself as others see him; (*c*) respect the balanced judgments of others even when these do not coincide with his own; (*d*) realise the advantages of tact in dealing with others, especially those under his control; and (*e*) weigh his decisions carefully but quickly in cases requiring prompt action.

It is maintained, however, that experience is enormously facilitated in these and other respects by having a large body of knowledge to draw upon; and it is for this reason that stress is laid throughout this paper on the study of sociology as an asset to those who would successfully manage their fellow men.

Study and Reading.—It is probable that neglect in this regard is chiefly due to the complete lack of indication as to the course of study to pursue. Sociology covers a vast and bewilderingly intricate field, including, be it noted, more nonsense than any other field of human enquiry. What are the fundamental principles which will guide the inquirer through the maze to the information he needs?

Now in the study of physical science the engineer soon found that the Theory of the Conservation of Energy was the link which brought harmony and simplification to an otherwise irresolvable complex of detail. It became the nucleus about which he arranged his knowledge in an orderly fashion. Without it he would only have acquired a meaningless smattering of knowledge in various directions leading as likely as not to futilities such as the search for perpetual motion. In precisely the same way many people seem to be at the mercy of uncorrelated smatterings of sociological science. They are like the man of whom it was said that he "thinks in little pieces that lie about loose, and nothing has any necessary link with anything else in his mind." Yet the idea which illuminates and links up all sociological study is no more than the Theory of Evolution. It may seem a far cry from this to the functions of management; but once let the student grasp the real implications of such expressions as "the survival of the fittest"—commonly but quite erroneously supposed to imply survival of physical strength or mental ability—"adaptation to environment" and "adaptation of environment"; let him further realise that human relationships are about as permanent as the shapes of the clouds in the sky, that human beings are individual and unique, and that human affairs are therefore less amenable to classification and tabulation than the properties of matter and energy—let him once get as far as this and he will henceforth pursue his studies with confidence. He will no longer be blinded by a dull acquiescence in the familiar appearance of things. He will realise that life is not static but kinetic; that the social, political and industrial conditions of to-day are not permanent; and unless he can in some measure forsee and help to determine the conditions of to-morrow, by so much will he fail to function successfully as a manager. Simple historical facts—such as, for example, that one hundred years ago trade unions were criminal offences against the law, that the population of England and Wales was about that of Greater London to-day—such elementary facts, by emphasising the rapidity of secular change, must profoundly modify the manager's whole outlook on the things of to-day and to-morrow. In the same way his excursions into crowd psychology, industrial and geographical economics, political theory and so forth, must inevitably widen his circle of thought and not only make him a more efficient manager, but more valuable as a citizen. An uneducated mind is in general a narrow mind, making for suspicion, intolerance, obstruction and all those kindred evils which stand in the way of sane progress and development. Modern industry has no use for a narrow outlook, and in this respect, at least, the manager must "get on or get out."

And through all his reading the student will find the theory of evolution the cement which will bind his ideas together. It is the touchstone that will enable him to read critically, and distinguish between science and pseudo-science. For most of the fallacies regarding human relationships arise through the attempt to regard such relationships as static rather than kinetic. Instead of being at the mercy of popular fallacies, he will have arrived at sound conclusions as to social theories—and will have fitted himself to guide the enterprise he manages, through the storms of industrial conflict to peace.

It may perhaps be advantageous at this juncture to consider a concrete example. We will suppose that a group of employees are threatening to strike. Your uneducated "practical" man, full of the zeal of ignorance, is all for immediate action, say "sacking the ringleaders," and in extreme cases he will erupt opinions such as that "workmen should be horsewhipped every morning to keep them in their place." Such a man is first cousin to the "practical" motorist, described in a recent novel, who put pebbles and road scrapings into his petrol tank to raise the petrol level when his car was stranded. Mr. Hilaire Belloc has described the uneducated "practical" man, with some exaggeration perhaps, but also with a considerable measure of truth, as one "suffering from two disabilities, the inability to define his own first principles, and an inability to follow the consequences proceeding from his own action."

Now a manager educated on the lines we have indicated, would realise that whatever the immediate causes of the strike, no action is isolated from events that have happened previously; and he visualises the immediate trouble in its proper relations to contemporary and past industrial events. He has familiarised himself with the prevailing mode of thought among the working classes—collectivism, syndicalism, guild socialism or what not—and for a vague resentment and dislike he has substituted a clearly defined and reasoned difference on some points, and probably agreement on others; thereby narrowing the issue and eliminating friction in regard to unimportant details. In his limited field he exercises the qualities of statesmanship by looking before and after, planning and keeping his counsel, and grasping the essentials of the situation. It is a maxim alike of warfare, statecraft and sport, that to understand your opponents' motives and methods is to win half the battle. In industrial strife it certainly takes one more than half-way to a peaceful solution. Muddled thinking and ignorance leads the manager to anarchic action as surely as it does the working man.

While it is no doubt true that the manager is in many respects born, not made, yet it is submitted that the old type manager and leader of men, who relied partly on his intuition and native sagacity, and partly on the ignorance of those he commanded or led, will be more and more at a discount with every step forward in working class education, unless he is prepared to broaden the basis of his management by some such educational development as is outlined herein. The exceptional men under him are undoubtedly reading and thinking. That they frequently arrive at wrong conclusions is all the more reason why the manager should be in a position to show that this is the case. On the other hand, many are educating themselves in sociological matters on right lines. Taking this fact into conjunction with the ever-growing facilities for technical education, it seems reasonable to suppose that the old type manager will presently find himself less suited to his job than some among those he is supposed to control. Biologically speaking, a manager who fails to fit himself to cope with a changing environment becomes unfitted to survive.

In conclusion, the writer would disclaim any originality in the ideas he has briefly indicated. The factors making for leadership and management are in general the same for an engineer as for others. And though great leaders of men in all ages have differed in many respects, the majority will be found to have held this one belief in common: that other things being equal, those with the widest education make the most successful managers of their fellow men.

THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

(*Continued from page* 134.)

In this article we propose to deal with the works and equipment, and may at once refer to Figs. 1 to 4 annexed, which are plans of the factory as it at present exists. These plans are not quite complete, as in the upper left-hand corner of Fig. 1 another independent shop should be shown. This extra shop, which is known as the North-west Works, has been omitted, partly because it is a plain rectangular building, a plan of which would not greatly add to the interest of our figure, and partly because, although at the present time it forms part of Messrs. Barr and Stroud's premises, it does not belong to the firm, and will, we understand, ultimately be vacated. This North-west Works was built by the Admiralty during the war to facilitate increase in the output of large naval range-finders, and has been and still is operated by the firm as an integral part of their factory. The building, however, is quite independent of the firm's own shops, and, as we have said, is not likely to form a permanent part of them. This North-west Works will be adequately illustrated in some of the photographic illustrations to which reference will be made in a later article.

Turning to Messrs. Barr and Stroud's factory proper, as illustrated in Figs. 1 to 4, it will be seen that it consists of a main works standing on an isolated site bounded on three sides by streets. The fourth (east) side is bounded by railway sidings. There is also an independent building to the west, on the far side of Crow Road, which is known as the West Works. Considerable parts of the main building, as well as the whole of the West Works, were erected during the war. The extensions of the main works were, briefly, the tube shop and the eastern half of the machine shop; the glass-annealing shop, engraving department and other buildings on the north side, with the exception of the dining hall and kitchen; the range of buildings on the east side, embracing the sub-station, packing shops, &c.; the ground floor drawing-office and heat treatment shop on the south side. The shops and offices comprised in the first and second floor flats were also about doubled in area by extending the various arms outward. Cross-sections through the works are given in Figs. 5 and 6 on the opposite page, while general exterior views are given in Figs. 9 and 10 on page 200.

In describing the works it will be well to deal with each shop more or less independently, following through, as far as possible, the manufacture of the instruments from the foundry and material stores to the packing shop. Before doing this, however, we may refer to the power supply arrangements, since they necessarily concern the factory as a whole. Electric driving and lighting is in use throughout, power being obtained from the Glasgow Corporation mains. A sub-station, which is illustrated in Fig. 7 on page 199 and the position of which can be seen on the Crow-road frontage in Fig. 1, contains two 500-kilowatt Bruce Peebles' rotary converters, which supply continuous current at 500 volts. They are supplied with 6,500-volt three-phase current from a high-tension switchboard, which is fed direct from the Corporation mains. The high-tension switchboard is of the enclosed cubicle type, and can be seen in the foreground in Fig. 7. There is also a 1,000-ampere continuous-current feeder, which supplies current direct from the Corporation low-tension mains to the sub-station switchboard. This switchboard contains six main feeder panels, which feed the distribution boards in the shops from which the circuits to the local lighting and power switchboards are run. All line shafting is driven by motors working on the 500-volt circuit, while lighting is run between the outers of the 500-volt circuit and neutral in the usual way.

In addition to the main circuits there are 30-volt, 20-volt and 10-volt three-wire circuits, which are used for finger lamps, instrument testing, clock circuits, &c. These circuits are supplied from two 40-ampere 20-volt generators, which are direct coupled, one on either end, of a 3 h.p. motor. These machines supply a switchboard fitted with switches, resistances, &c., which allow the three low voltages to be maintained. There are also two additional generators direct coupled to 2 h.p. motors, with capacities respectively of 100 amperes at 10 volts and 40 amperes at 10 volts to 25 volts. These supply current to the electro-plating department. The total power consumption, including lighting, reached a maximum of 36,000 Board of Trade units in one week during the war period. This dropped to an average of 21,000 units after the Armistice was signed. The highest peak load during the war, in November, 1918, was 1,200 amperes. The present average peak load is 750 amperes.

The administrative offices are situated in the three-story block facing Caxton Street, which is illustrated in Fig. 10. Part of this building formed part of the original factory which was built in 1904. The office entrance is in this building, which contains the various directors' offices, general offices and drawing offices on the ground and first floors as will be seen from Figs. 1 and 2. The drawing office is on two floors, the two rooms, however, communicate by means of an inside stairway, and there is no need in passing from one room to the other to go into the general office part of the building. The lower room is used, in the main, for design work in connection with jigs and other manufacturing matters, while in the upper design work is carried out for the various instruments. The drawing office arrangements do not call for much comment. Illumination is by incandescent lamps suspended over each board. The upper room has a large blackboard hung on the end wall, which is utilised to a very considerable extent in working out the preliminary stages in the design of new apparatus. There is a large fireproof store room with metal racks for drawings leading out of the lower room. Tracing, printing, and photography is done by girls who sit in a separate office.

The pattern-shop and foundry are situated on the east side of the main works. Access to them for material arriving from outside is had by a wide passage which runs right across the shops and communicates with the main shop entrance in Crow-road. The pattern shop is used both by the pattern makers and by the cabinet makers who build some of the large number of polished wood cases in which the range-finders and other apparatus are supplied from the works. The capacity of this shop does not allow the whole necessary cabinet-making to be undertaken in the factory. The machinery equipment of the shop consists of the usual circular saws, lathes, grinders, wood-trimmers, &c. There is an interesting and convenient pattern-makers lathe, direct driven by a motor in the head-stock and having no belt or other gear. Speed variation is obtained by regulation of the electric circuit. The shop is fitted with sprinklers and is lighted by metallic filament lamps.

Fig. 1. GROUND PLAN.

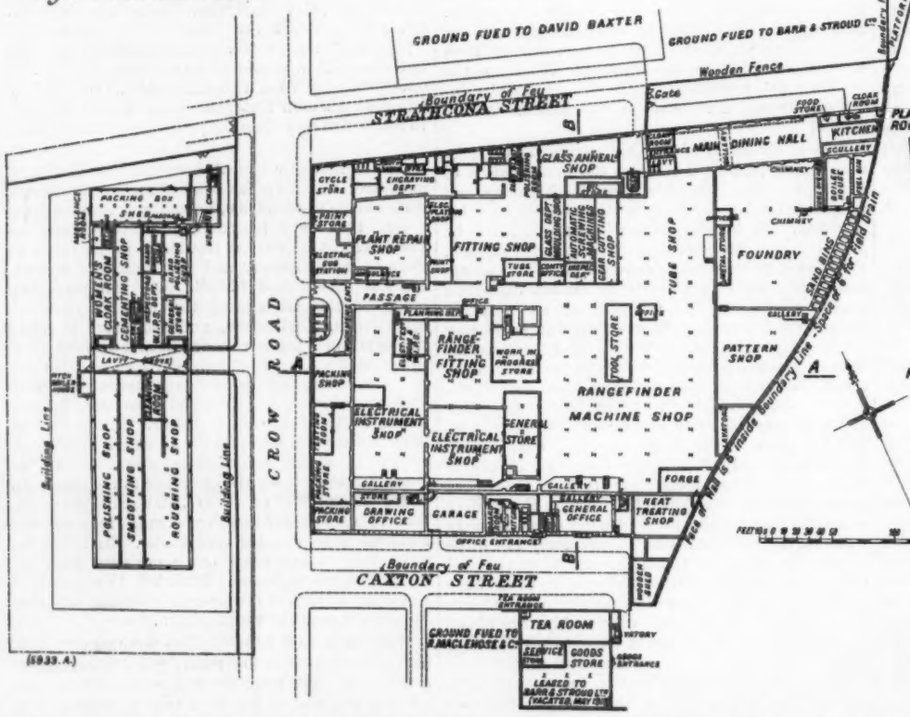
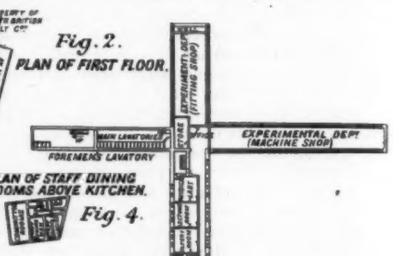
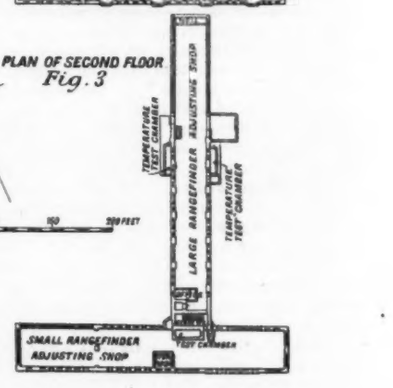


Fig. 2. PLAN OF FIRST FLOOR.



PLAN OF STAFF DINING ROOMS ABOVE KITCHEN. *Fig. 4.*

PLAN OF SECOND FLOOR *Fig. 3*



THE WORKS OF MESSRS. BARR AND STROUD, LIMITED, ANNIESLAND, GLASGOW.

(*For Description, see opposite Page.*)

Fig. 5. SECTION A.A. (*Fig. 1*)

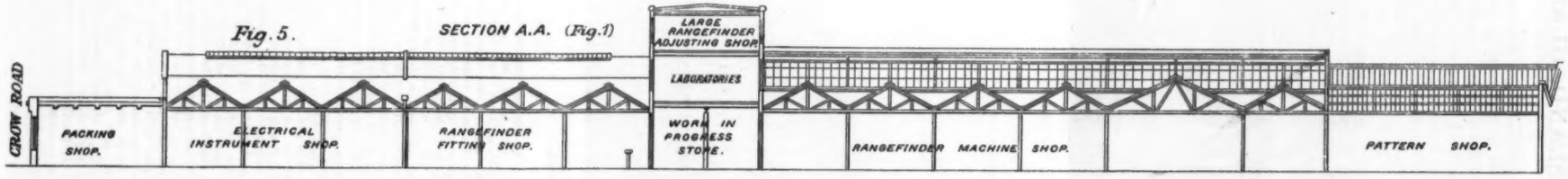
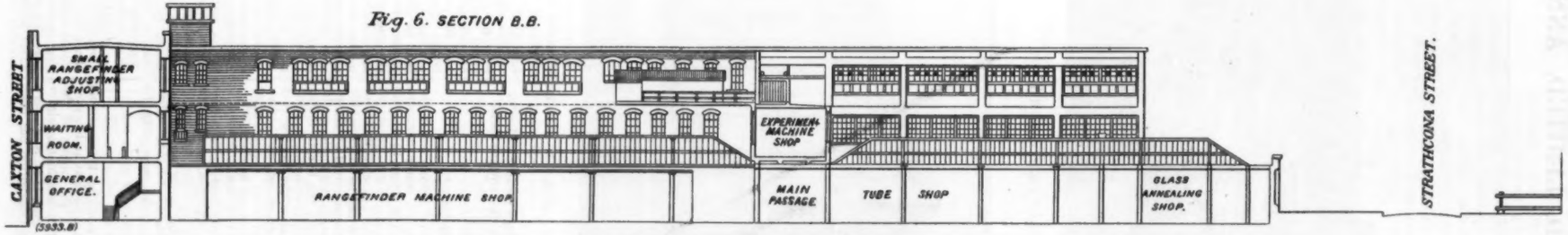


Fig. 6. SECTION B.B.



FIGS. 5 AND 6. SECTION AND ELEVATION OF WORKSHOPS.

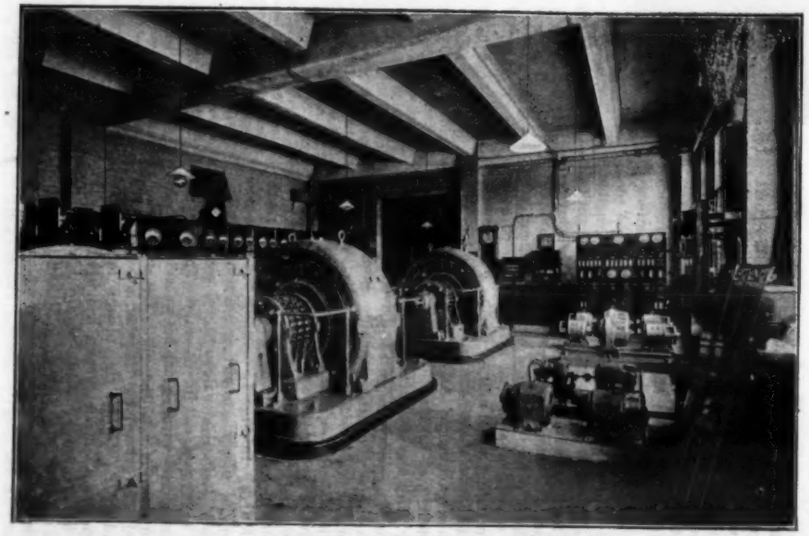


FIG. 7. SUB-STATION WITH ROTARY CONVERTERS.

FIG. 8. THE FOUNDRY.

THE WORKS OF MESSRS. BARR AND STROUD, LIMITED, ANNIESLAND, GLASGOW.

Fig. 9. General View of Main Works from North-West.

The foundry is illustrated in Fig. 8 on page 199, which is a view looking north. The roof is all glass and as the walls are white and are kept white, the lighting is unusually good. Artificial lighting is by half-watt and mercury vapour lamps, the half-watt lamps supplying the red ray in which the mercury lamps are lacking so that a good general colour is obtained. The floor is of concrete. The plant is in the main of a size suitable for producing and dealing with medium-sized or small castings, as, of course, very heavy parts do not normally enter into the construction of range-finders. A number of moulding machines are installed, including two Tabor rock-over machines, three hand operated drawing machines and a Tabor dumping machine. This latter machine is set in the floor. Plate patterns are very largely used as there is much repetition work, especially among the smaller parts. Vibrators have been added to a number of the moulding-bins and are found to appreciably decrease the time required for hand-drawing and to result in a better job.

The lifting arrangements consist of a three-ton electric crane and a hand-operated overhead runway system. The runway tracks are carried on the roof framing. For melting, there are a number of crucible furnaces below floor level and a Morgan tilting furnace fixed in the metal store and used for alloying and ingoting. There is a very complete installation of auxiliary plant, consisting of a saw, emery and buffing wheels, a sand blast and an ash-separating plant, including a ball mill for crushing the cinders. Dust extraction apparatus is fitted in connection with this machinery. An air-compressor for the sand blast and pneumatic plant is also in the foundry. All the machinery is driven from overhead shafting, which in turn is driven by a motor fixed in the neighbouring machine shop. Most of the work turned out is brass, gun-metal, and other alloys, but some iron-founding is done. There are baths available for the use of men working in the foundry. Tickets of admission are sold at 10 for 3*d*.

The boiler house, seen at the north-east corner of the foundry in Fig. 1, contains the apparatus for warming the works. There are two 10 ft. 6 in. diameter cylindrical dry-back return tube boilers working at 80 lb. pressure. These supply steam to calorifiers from which hot water is circulated by pumps to the various shops. The shop heating is mostly carried out by overhead hot-water pipes and radiators fed from this plant; but in some departments a hot-air system has been installed which is operated by steam obtained from these boilers. Some of the steam is also utilised for a low-pressure steam heating system which is chiefly employed for warming the offices. For this purpose the 80 lb. steam is passed through double reducing valves and brought down to 5 lb. per square inch.

(To be continued.)

Fig. 10. Administrative Building.

Rapid Analysis of Bad Air in Rooms.—For the rapid analysis of the unhealthy air of confined rooms, E. Kohn-Abrest (Comptes Rendus, 168, pages 1019–1022) makes use of an asperator vessel of 5 litres' capacity; from this vessel issues a tube which branches into four smaller tubes, each provided with a tap to which a bulb can be attached. Carbon dioxide is estimated by means of baryta water; air bubbling through this liquid at the rate of 2 litres per hour would render the baryta turbid in 2 minutes, when four parts of CO_2 are present in 1,000 parts of air, and in 20 minutes, when the CO_2 content is only 5 in 10,000. The determination of carbon monoxide is combined with that of CO_2; the air, after passing through the baryta, is sent through an electrically-heated tube containing iodic acid and again through a baryta bulb; both the iodine and the barium carbonate deposited have to be determined. Other injurious gases like sulphuretted hydrogen, sulphur dioxide, &c. would be arrested by the bulbs containing silver nitrate and potassium permanganate, both highly diluted; when both these liquids remain clear, such gases may be assumed to be absent.

International Air Navigation.—The International Convention for the Regulation of Air Navigation has now been issued for the information of the public of the allied and associated States, and is obtainable, either directly or through any bookseller, from H.M. Stationery Office, at a price of 9*d*. net. The Convention has been agreed to, subject to certain reservations, by all the representatives of the allied and associated Powers serving on the International Commission dealing with aerial navigation, which was appointed as a sub-commission of the Peace Conference, but has not yet been formally approved by the Supreme Council of that body. The published document outlines the general principles upon which international aerial navigation is to be conducted, and defines the conditions which will govern the nationality of aircraft. It also deals with the questions of certificates of airworthiness of aircraft and competency of pilots and navigators, as well as such matters as rules of the air, lights and signals, marking of aircraft and landing places, customs regulations, maps and meteorological information. With regard to the certificates of airworthiness, the exact conditions governing their issue are not yet decided. Eventually they will be fixed by an International Commission for Air Navigation, which will be a permanent body instituted as part of the organisation of the League of Nations; in the meantime each contracting State will make its own regulations in this respect. All aircraft engaged in public transport, and capable of carrying 10 or more persons, will be required to be fitted with wireless apparatus, both for sending and receiving, as soon as the methods of employing this apparatus have been determined by the International Commission. Many other matters will be dealt with by this body, which is to be composed of two representatives each for the United States, France, Italy, and Japan, one representative for Great Britain, and one for each of the British Dominions and India, with one representative for each of the other contracting States. The duties of the Commission are set out in the Convention, and it is also stated that the expenses of organisation and operation will be borne by each State in proportion to the number of votes at its disposal.

TOLERANCES AS AFFECTED BY WORKSHOP CONDITIONS.

By A. WHITEHEAD.

THERE are several ways of showing tolerances when dimensioning drawings; a common tendency seems to be to adopt the form $D \begin{smallmatrix}+m\\-n\end{smallmatrix}$, where D is the desired size and m and n are the permissible errors above and below respectively. The theory is that the size D is the best, though small variations either way are tolerable; that the workmen will always aim at D and, as a consequence, will on the whole keep nearer to it than if the maximum and minimum sizes only were given. Whether this is realised in practice depends on several factors. This article deals only with shafts and holes such as are common in motor chassis and smaller work, under the conditions associated with intensive production.

It is proposed to show that there is a considerable difference between the tolerances given on drawings and those actually available or used in the shops when the limits are close. When the limits are wide, the discrepancy is generally insignificant. The relations between the nominal and the real tolerances depend on:—

1. The preparation of working drawings particularly with reference to the system of dimensioning.
2. The kind of gauges used.
3. The practice and tradition of the particular works.

A drawing can only represent the principal features of anything, and varying shop tradition and practice will naturally tend to give different expressions to those features. For instance, if three firms were required to make in quantity a simple machine, and were given a similar set of drawings and gauges, it is more than probable that the products of each would be distinguishable without any measuring, by reason of their different rendering of minor details. And if carefully measured, it would surely be found that each had its peculiar tendencies, although every part might be correct to gauge.

Again, a firm may have made large numbers of a machine from their own drawings quite successfully, yet find that another to whom they have supplied copies, meets various unsuspected difficulties or even errors. This is not necessarily because one's shop practice is better than another's, but because men in the workshop acquire by experience special knowledge, and traditions are established which frequently remain unknown to their officers, or if known, remain unrecorded. Drawings cannot be made absolutely perfect; something is always left for the leading men in the shops to determine. They will be guided according to their knowledge of the functions of the parts which the drawings represent. If their knowledge is clear and accurate, the products are likely to be satisfactory, even with poor drawings. But if they are working more or less in the dark, the results will certainly be very costly and probably unsatisfactory in quality.

Although full, clear drawings may cost two or three times as much to prepare as inferior ones; they are sure to repay more than the extra cost by the time saved in the shops, for imperfect drawings lead to expense in several ways:—

1. Mistakes by workmen engaged in production, and others, *e.g.*, tool draughtsmen.
2. Restricted output through fear of making mistakes.
3. Bad feeling between departments.

Expenses caused in this way are not easily discerned, but the drawing office wages bill is brought to notice every week, and frequently the obvious expense will be controlled to the general detriment.

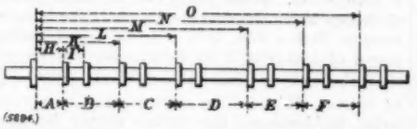
Of course, after a sufficient period, which may be a few months or a few years, traditions will become established and relieve the situation. But under competent direction, proper drawings would have brought success more quickly.

For intensive production, it is desirable for the drawings to show the more complicated components as they will appear at different stages of production. For instance, a crankshaft may well have drawings showing it as it will be after: (1) forging; (2) rough turning and milling; (3) finish milling and turning; (4) boring and drilling; (5) grinding. But it is always a great convenience to have one drawing which shows all the finished sizes besides. Separate drawings for every stage in production are neither necessary nor desirable. But it is impossible to avoid overcrowding or to arrange the dimensions so that measurements can always be taken from real surfaces without calculations in the shops, unless there are sufficient stage drawings.

To make the matter quite clear, imagine that a case-hardened shaft is to be soft in certain parts. Some works employ the copper-plating process for selective case-hardening, but the more usual practice would be to allow not less than $\frac{1}{16}$ in. excess metal on each surface required soft, and to remove it after carburising. After the final heat-treatment the shaft would be finally machined. And either the allowance will be made at the discretion of the men in the shops, or three sets of dimensions must be given on the drawing. The presence of three sets is often disguised by giving one set (the final sizes) with notes showing the allowances to be made during the different processes, thus leaving calculations to be made in the shops. To do the calculations and record the results permanently on drawings at the very commencement is in every way cheaper and better. Even the simple arithmetical process of reckoning the allowances will be done in the shops very slowly, without certainty and worse still, it will be often repeated as men strange to the work attempt it, or others find it desirable to refresh their memories.

Again, by having three separate drawings, appropriate limits can be affixed to the dimensions for each stage. If, on the other hand, the final sizes were given with their tolerances, and notes stated the allowances to be made for the different stages, it is a certainty that the turner would work much finer and, therefore, more slowly than necessary for the earlier operations. To some extent the gauges can be arranged to take care of the allowances and the tolerances; but it is not wise to have gauges which do not correspond with dimension directly stated on a drawing. It inevitably leads to confusion and delay sooner or later, and to many repetitions of the calculations to prove the relationships.

Fig. 1 represents a camshaft for an internal combustion engine in an early stage of production. Suppose at this stage the limits of error on each



(5894.)

dimension H K—O were $\pm 5 \times 10^{-3}$ in. Then the lengths B C—F could vary $\pm 0{\cdot}01$ in. The spacing of any two pairs of cams could not be more than 0·01 in. wrong.

But a common way of dimensioning such a shaft is to give the dimensions, A B—F. If the limits for each were $\pm 2 \times 10^{-3}$ in., the errors in spacing may accumulate so that the extreme pairs of cams were spaced 0·01 in. too wide or too narrow. That is to say, in this example, the tolerances in the one system of dimensioning could be larger than those in the other system in the ratio of 5:2, with about the same results. The cost of making drawings would be the same, but the shaft made to one could be machined more quickly than that made to the other.

Although the whole of this apparent advantage would not actually be realised because the spacing would be partially determined by stops on the machine, the system of avoiding cumulative errors as much as possible is obviously right in principle and important in practice. Yet it is overlooked more often than not.

To consider the effect of different kinds of gauges on tolerances, it will be simplest to take a concrete example. Imagine that a shaft is to be ground to the diameter $0{\cdot}4997 \begin{smallmatrix}+0.0002\\-0.0003\end{smallmatrix}$ in., and ignore at first the elements of roundness and parallelism.

If a 1-in. micrometer be used the grinder will probably aim at the size 0·4997 in. immediately after trueing his wheel. As it gradually wears, his size will increase until it is at the top limit; then he will operate his machine to a new reading, aiming at the ideal size again. When a number of the shafts were finished the grinder might consider that about 3 per cent. were extremely near the low limit, perhaps 20 per cent. between that and the ideal size, 10 per cent. at the top limit, and the balance just under that. These are roughly the proportions reasonably to be expected.

Now let these shafts be examined by an inspector of about the same grade of skill as the grinder, using the same micrometer. He may be expected to confirm the grinder's opinion generally except that he might find one or two just below the low limit, and perhaps two or three more too large, the grinder having deceived himself a little. But if the shafts were taken to a superior workman thoroughly skilled in fine measuring to be inspected (still using the same micrometer) the probability is that his readings would average not less than 1×10^{-4} in. higher than the grinder's owing to his more highly cultivated "feel." He would reject several, perhaps, for being too large, and possibly pass those previously considered too small.

Since the same micrometer was supposed to be used throughout, the errors in the instrument have not entered; it is only the personal element which has varied, and it is a general rule that a less skilful workman usually obtains a slightly lower reading in measuring a shaft diameter with a micrometer than one of superior skill.

The practice in most works is for micrometers to be examined and adjusted, if they require it, once a week. This rule, of course, cannot rigorously apply to those which are the private property of workmen. Mechanics universally take a pride in their tools, and keep them carefully, but still there is a weakness in this lack of control, excepting perhaps in the case of workmen of the very highest grade. Although viewing provides a safeguard there is the danger that in passing a sample piece the inspector might report that it was within the limits, and fail to state what he considered the size to be, so that the difference between his and the workman's micrometer might not be brought to light until a quantity were finished incorrectly.

But even although the practice of weekly adjustments is rigorously adhered to, it by no means follows that uniformity results. There is the obvious fact that before the adjustment was made the micrometer was being used although incorrect. Of course, a skilled workman should discover and make the allowance to the reading himself if the error be one of adjustment only. And to some extent the effect of the personal element is reduced by knowledge of the particular micrometer used, but it is always present. The "feel" of a 1-in. micrometer at zero is not quite so sensitive as when measuring a shaft, and it requires considerable experience and skill to be certain if it is set right or not. The so-called 1-in. reference discs frequently supplied are usually about 1×10^{-4} in. too large, but vary considerably. Many men do not care for ratchet stops, considering them too coarse for fine work.

If the common rule be followed of handing in all micrometers to stores on Saturday to be reissued on the following Monday morning as early as possible after adjustment, there is not the time for proper care to be taken in examination. This can be got over by grading those used on specially fine work separately from the rest, so that they can receive better attention; and if organised and done properly this is a fairly satisfactory solution. Thus, after a period of service in the first grade, each micrometer may be transferred to the second grade for general use, being etched with a distinguishing mark to signify the change. Whatever solution be adopted, it must be impossible for any works micrometer to miss frequent examinations by the men responsible for maintaining all in good adjustment.

In adjusting micrometers it is usual to set them to read correctly at one extremity of their scale, the 1-in. size being adjusted at zero, the 2-in. size at 1 in., and so on. This practice fails to take into account errors in pitch.

A new micrometer of reliable make may be assumed to have little error in pitch throughout its range. It is likely to retain its truth for a long period if carefully used for miscellaneous sizes. But if used continually round about one size, it will wear unequally, and have to be relegated to the second class after a very few weeks. On the other hand, the pitch errors in new micrometers of inferior make are likely to be over 2×10^{-4} in. in a 1-in. range, and may vary at intermediate points in a freakish way. Not all the sources of error in measuring with micrometer gauges have been mentioned. Perhaps, however, no more are needed to show the uncertainties in the process.

One of the advantages claimed for snap limit gauges is that little skill is required to determine whether a shaft diameter falls within the designed limits or not. This is only reasonably true when the limits are wide compared with the probable incidental errors.

To continue with the small shaft and considering first of all the personal element, the gauge being supposed perfectly made with the jaws exactly 0·4999 in. and 0·4994 in. wide respectively. There would be no difficulty at all with the shafts near mean size. But the difference in feel over shafts measuring 0·4999 in. and 0·5000 in., though perceptible, would be too small to expect any but highly skilled men to detect. Similarly there would be room for disagreement over shafts a trifle small. In practice, therefore, an exceedingly conscientious workman would leave no room for doubt by trying actually to keep within finer limits than essential (probably 0·4998 in. to 0·4996 in.), which means that he would take longer, so the shaft would cost more than necessary. He would keep as far as possible from the low limit (hence the dimension 0·4996 in. instead of 0·4995 in.) in common with a less careful man, who would no doubt push the gauge over shafts measuring 0·5001, and be quite contented. And it would frequently happen that the latter's practice would not be so entirely unreasonable as may be supposed, because he might often be able to demonstrate that at a certain place the diameter of the shaft did fall within the limits, and he could argue that if he ground any more off it might be too small and consequently scrapped.

For to keep the shafts fairly round and parallel, so that the difference between the maximum and minimum diameters was not more than about 15×10^{-5} in. on any one shaft, would be quite good for ordinary repetition work under favourable conditions; that is, if the centres in the ends had been drilled with reasonable care, the shaft were stiff, and the grinding machine in good order, and well operated.

In practice, as might be expected, a great many of the shafts would be within the limits at one part and outside at another, so that to inspect them properly, judgment and discretion would have to be exercised.

Every time after trueing his wheel, the grinder would proceed as follows:—

1. Take a trial cut.
2. Measure the resulting diameter.
3. Take a second trial cut with the wheel adjusted as he estimated necessary.
4. Measure again.

If necessary repeat 3 and 4 until satisfactory.

This sequence of operations shows up one disadvantage inherent in the fixed snap gauge as compared with the micrometer; by using a micrometer at the second operation, the operator can tell almost exactly the number of graduations by which he must advance the wheel to make the work the correct size, whereas with a fixed snap gauge he can only guess and will often have to repeat operations 3 and 4 several times in consequence. The cost, not the accuracy of the finished work, would be affected, but the point is worth mentioning.

The process of lapping snap gauges by hand is very expensive, but it necessarily follows grinding if the jaws are to be made nearer the correct width than about 2×10^{-4} in. And lapping gives a better and more durable surface. Taking all the factors into consideration, however, it is probably cheaper to use micrometers in preference to snap gauges when the limits are less than about 3×10^{-3} in., and when snap gauges are used to take them straight from the grinding machine without lapping.

Even with skilful lapping, it is very difficult indeed to make the jaws of snap gauges fairly parallel and within 1×10^{-4} in. of the desired size. Since it is usually considered undesirable for a gauge to pass work outside the drawing limits, the toolmaker would try to make the "go" end of the gauge smaller than its nominal size, to allow for wear and the "not go" end on the average would be larger than its nominal size. The effect is to reduce the tolerances on the work being produced, and thus to increase the cost, which again tells against the fixed gauge.

Perhaps one of the most valuable attributes of this gauge is that it has no value for any purpose other than that for which it was made, consequently is not worth stealing. It should be quite clear that of the nominal tolerance of 5×10^{-4} in. very little would be really available since

Reduction in tolerance due to errors in gauge	= 0·0001 in.
Reduction in tolerance due to "feel" of gauge	= 0·0001 in.
Difference between maximum and minimum diameters of work	= 0·00015 in.

Thus the real tolerance would only be 15×10^{-5} in., and as previously stated, in practice more tolerance would frequently be allowed, or, to put it more diplomatically, the readings would be taken in a generous spirit.

The errors attending limit plug gauges are similar to those just mentioned in dealing with snap gauges. It is not very difficult to grind plugs to the desired size within 1×10^{-4} in., and if a suitable wheel is used for finishing, lapping is quite unnecessary. The worst trouble experienced in an ordinary tool-room is to grind them round and parallel. The usual practice is to make one end of the limit plug gauge the same size as the minimum diameter of a hole, and the other end the same size as the maximum diameter. For a hole of diameter $1{\cdot}000\ ^{+{\cdot}001}_{-{\cdot}000}$ in., the aim would be at making the "go" end between 1·0001 in. and 1·000 in., and the "not go" end between 1·001 in. and 1·0009 in., though gauges would often be accepted and used which were not within these limits. It will be noted that this arrangement gives the benefit to the "go" end of allowing for wear, and the tendency is to reduce the actual workshop tolerance at both ends. It would not be far out to say that in practice less than three-fourths of a nominal tolerance of 1×10^{-3} in. would really be available in the workshop under the best conditions. For instance, imagine that a 1-in. hole is to be bored through pieces of cast-iron 1 in. thick. We will suppose that the hole is dimensioned thus, $1{\cdot}000\ ^{+{\cdot}001}_{-{\cdot}000}$ as before. If the holes were reamed in a turret lathe, for instance, the reamer should be about 1·0007 in. to commence with to cut a hole near the largest permissible size. At first a reamer generally wears comparatively rapidly, so that after the first few the holes would be little above the mean size. Then wear would take place more slowly.

While these are the general conditions the result would be complicated by irregular variation caused by:—

1. The method of mounting the reamer.
2. The preparation of the hole before reaming.
3. The nature and want of uniformity of the cast-iron.
4. The general design of the reamer.
5. The form and preparation of the cutting edges.

It may be assumed that the piece of cast-iron is chucked without strain in a machine which is in good order and properly operated.

If a quantity of holes thus produced were carefully examined, it would be found that even if all the elements susceptible of control by the machine shop had been well attended to, most of the holes were bell-mouthed and not round. A certain proportion would satisfy the gauge fully; that is to say the "go" end would pass through and the "not go" end would not more than just enter the bell-mouthed part. Those holes which admitted the "not go" end of the gauge for the greater part of the length, but without perceptible shake would frequently be considered passable, though not desirable. They would be passed under protest.

Some firms insist on the small end of the gauge being no tighter than a light push fit through the holes; others accept what very nearly amounts to an exceedingly light driving fit.

From every point of view the latter is an expensive practice, but is justified on the ground that otherwise the effective tolerance is reduced. It is better to insist on the light push fit and make the "go" end rather less than its nominal size. In the case under consideration, the allowance should be about 2×10^{-4} in. This allowance on the gauge will not under workshop conditions result in holes being passed under size, but there must be no suspicion of any force beyond that required for an easy push fit. The case would be different if the holes could be carefully cleaned and lubricated before inserting the plug.

If this small adjustment to the nominal size of the "go" end be not made and holes are accepted which admit the "not go" end without shake, the actual dimensions being worked to would be well over drawing sizes. If the extended top limits be not allowed, the tolerances would be reduced; we should have:—

Reduction of tolerances through errors in gauge	0·0001 in.
Reduction of tolerances through "feel" of gauge	0·0002 in.
Leaving an available tolerance of	0·0007 in.

and this assumes first-rate gauges and that a slight amount of "bell-mouthing" in the work is not detrimental.

With regard to the amount of discretion which should be used by inspectors, it is universally agreed that they must have some latitude to interpret the drawings in a broad spirit. Some go so far as to fix one set of tolerances for the machine shop and another for the inspector's use; others allow inspectors only the tolerances on the drawing, and cases where they have been exceeded are dealt with specially on their merits by a qualified officer.

The second is by far the better plan; it gives the advantage of wider limits, and is satisfactory from a disciplinary point of view. But the first-mentioned has several disadvantages:—

1. It requires different sets of gauges or different means of measuring for the machine shop and the inspection departments.

2. It is only a question of time for the machine shop to find out the tolerances actually allowed, and to work accordingly.

3. It implies and encourages want of power to control.

Once having made a practice of extended limits, frequent dissatisfaction arises in the machine shop because "just a little more" is not allowed, and troubles frequently arise over the question of bonus or piece work payments.

But still an inspector must use some discretion; thus in the case of the small shaft he would take into consideration its functions and relation to other parts and make allowances accordingly. He might consider it essential for it to be entirely within the limits given or he might accept it if the tolerance had been exceeded by little and that only locally. It is unfortunate even so much discretion should have to be exercised.

Of course, the ultimate test is in erecting or assembling the parts, and the way they function afterwards. When tolerances are set in the first place by a draughtsman it is essential for an officer to revise them who knows the practical possibilities of manufacturing, as well as the functions of each component. Naturally, those fixing limits play for safety and make them finer than necessary as a general rule. They are, in fact, frequently absurdly fine.

To have all limits rigidly and narrowly adhered to is the ideal. But there is always a percentage of work just below the proper standard which it is impossible to scrap easily. Should it be expedient to use it there should be enquiry and plenty of ceremony, or the percentage of poor work is likely to grow rapidly. The bad tradition of "extended limits" is all too easily established. Once it gets hold, the highest economy of intensive production

can never be realised. If a coarse tolerance is feasible, adopt it. If not, scrap ruthlessly.

The application of many of the instruments for measuring shafts and holes is generally restricted by their structure. They are commonly very sensitive, but not handy, and introduce their own peculiar errors. It is not difficult to compare neighbouring sizes within 1×10^{-4} in. with a micrometer; but one must have something with which to make the comparison. A very good way is to have full size model components carefully made, and to have their actual sizes etched or engraved on them. They can serve several purposes; for instance, to show the class of finish desired; how such details as chamfers and grinding recesses should be made; and if the sizes are marked accurately, they will act as reference gauges by which the workman can test his instrument and his "feel." They must be marked or treated so that they cannot be taken into production by accident.

When a component is large or very expensive, the model need not be complete. It need be perfect in just the essentials to make clear the standard desired from any process and no more. But generally it should be a replica of the component as that ought to be immediately after the given process is completed. In any case models are only necessary for perhaps one or two processes on any component.

The greatest disadvantage of the scheme is, of course, the expense. Naturally that must be carefully considered, and since the returns would never be obvious, one could only surmise that loss of time or errors were sometimes prevented through having a model for reference. To many the idea makes no appeal.

There is another way of looking at it; a charge-hand giving a new workman a job will explain the drawings and the gauges, and probably place a sample before him; now this sample, though very useful, cannot act completely as a model. Not only that, but loss occurs through borrowing samples from the batch they belong to. Once borrowed, a sample probably will remain on the machine for a short time, and then be put on one side or knocked down. If very small it will probably be lost, if larger it may some day be reclaimed, perhaps at stock-taking if still useable.

It might be argued that the shortage in the batch would be noticed when it was passed to the next operation. Possibly, but in dealing with large quantities, the numbers are generally more or less approximate, and there is a big difference between noticing a shortage and taking the trouble to correct it. So that in effect more than the expense of having a range of models will have been incurred without the full advantage being reaped.

H.M.S. "FURIOUS."

ONE of the most interesting vessels added to the Navy during the war was H.M.S. Furious, by reason of her adaptation as a floating platform from which aeroplanes could fly and of her great speed, attained by the most powerful set of geared turbines in any naval ship yet in service. Much has been said of her, and she attracted great attention at the naval review recently held at Southend, but so far little has been published about the vessel, even in the informing paper read at the Institution of Naval Architects by Sir Eustace Tennyson d'Eyncourt, who designed this vessel and so many others of the new warships. The photographs we reproduce on this page and on Plate XII, and the description we are enabled to give of the ship and her machinery will be of special interest. Figs. 1 and 2 show the vessel as completed, Figs. 3 and 4 in an intermediate stage.

As originally designed H.M.S. Furious was intended to be an improved edition of H.M.SS. Courageous and Glorious, then under construction, and described in Sir Eustace's paper. The length given in the appended table was kept the same as that of the preceding vessels, but the beam was increased and the draught reduced by 6 in. The displacement was slightly in excess of her sister ships, but the principal difference was in the armament, which in the new vessel consisted of two 18-in. guns single-mounted in armoured gun-houses on the centre line of the vessel, one on the forecastle forward and one on the upper deck aft, eleven 5·5-in. guns, with shields, mounted in the open, and two 21-in. submerged broadside torpedo tubes, installed in a compartment forward. The armament proposed is interesting, inasmuch as the types of gun in both the main and secondary armament were new to the British service. Prior to the design of this vessel, the largest calibre of gun installed in modern British warships was the 15-in. gun in the Queen Elizabeth class and subsequent vessels. That the introduction of the 18 in. gun was regarded somewhat in the light of an experiment is seen in the fact that arrangements were made so that twin-mounted 15-in. guns could be readily substituted for the single 18-in. weapons if considered desirable. As the gun trials were entirely satisfactory, this provision turned out to be an unnecessary precaution. The 5·5-in. guns of the secondary armament, though closely resembling in calibre similar installations in several foreign navies, were, at that time, new to the British Navy, which had hitherto pinned its faith to the 4-in. and 6-in. gun.

This construction is intended to ensure, in the case of a torpedo striking the vessel, that it is exploded at a considerable distance from the protective bulkhead, and also provides a large air chamber in which the explosion gases can expand and cool.

The construction of the Furious was entrusted to the firm of Sir W. G. Armstrong, Whitworth and Co., who had under construction at that time H.M.S. Courageous, in addition to H.M.S. Malaya, H.M.S. Canada and several other important vessels for the Navy. The Malaya was the first battleship laid down in the new Armstrong Naval Yard, and, like the Furious, was supplied with her machinery by the Wallsend Slipway and Engineering Company, and the work was down almost in record time. The keel of the Furious was laid in June, 1915, at the new yard. The Admiralty desired that this large vessel should, if possible, be completed in about twelve months, and the firm were confident they could carry out the work within the allotted time. As the work progressed, experience gained during the war suggested the advisability of certan modifications being introduced, and somewhat delayed the progress. The vessel was launched in August, 1916, and shortly afterwards the growing need for vessels in the Navy capable of carrying aircraft resulted in the Admiralty deciding to convert the Furious into a seaplane carrier.

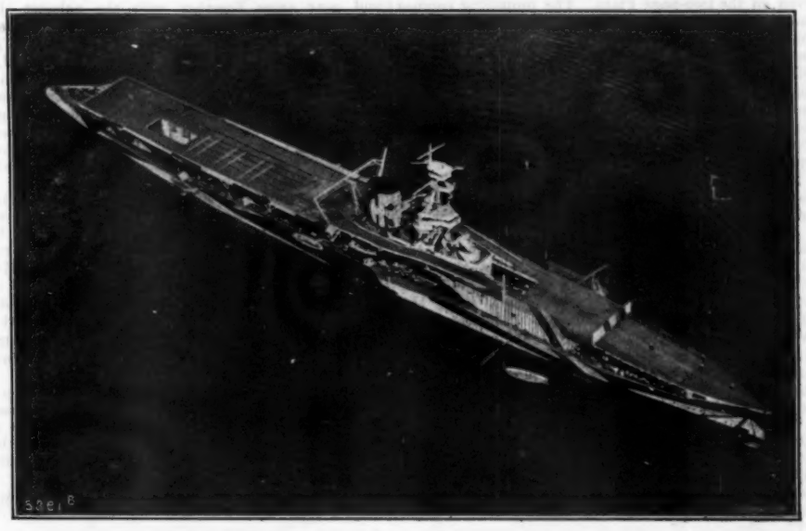


FIG. 1. H.M.S. "FURIOUS"; VIEW FROM AN AEROPLANE.

TABLE I.—*Principal Dimensions of Original Design.*

	Ft.	In.
Length between perpendiculars ...	735	0
Length overall	786	6
Breadth extreme (over bulge) ...	88	1½
Load draught, mean	21	6
Displacement	19,100 tons.	
Shaft horse-power	90,000.	
Speed at load draught	31¼ knots.	
Fuel at load draught	750 tons.	
Oil fuel capacity	3,400 tons.	

Armament.
One 18-in. gun in armoured turret aft.
Eleven 5·5-in. guns, single-mounted, with shields.
Two 3-in. H.A. guns.
Four 3-pdr. Q.F. guns.

Torpedoes.
Two 21-in. submerged broadside tubes, with five bodies per tube.

Searchlights.
Seven 36-in. projectors.
Four 24-in. signalling.
Two 10-in. signalling.

Armour.
Side, amidships, 3 in. thick H.T.
Side, forward, 2 in. thick H.T.
Bulkheads, forward and aft, 3 in. and 2 in. thick H.T.
Barbettes, 7 in. to 3 in. thick K.C.
18-in. gun-houses, 9 in. to 5 in. thick K.C.
Conning tower, 10 in. thick K.C.

Protection.
Forecastle deck, 1 in. thick H.T.
Upper deck, 1 in. thick H.T.
Main deck, 1½ in. to ½ in. thick H.T.
Lower deck, 3 in. to 1 in. thick H.T.
Longitudinal protective bulkhead, 1 in. thick H.T.

An essential difference between the Furious and the Courageous is seen in the provision made to protect the vitals of the vessel against torpedo attack. In the new vessel the protected side, extending from the forecastle deck to the water-line, is continued in a straight line to the outer bottom plating in the vicinity of the bilge in the form of a longitudinal protective bulkhead. Outside this protective bulkhead from the bilge to slightly above the normal water-line is worked a "bulge" or "blister" extending over the length of the magazines and machinery spaces and then dying away into the normal form of the vessel forward and aft. This construction is intended to ensure, in the case of a torpedo striking the vessel, that it is exploded at a considerable distance from the protective bulkhead, and also provides a large air chamber in which the explosion gases can expand and cool.

The construction of the Furious was entrusted to the firm of Sir W. G. Armstrong, Whitworth and Co., who had under construction at that time H.M.S. Courageous, in addition to H.M.S. Malaya, H.M.S. Canada and several other important vessels for the Navy. The Malaya was the first battleship laid down in the new Armstrong Naval Yard, and, like the Furious, was supplied with her machinery by the Wallsend Slipway and Engineering Company, and the work was down almost in record time. The keel of the Furious was laid in June, 1915, at the new yard. The Admiralty desired that this large vessel should, if possible, be completed in about twelve months, and the firm were confident they could carry out the work within the allotted time. As the work progressed, experience gained during the war suggested the advisability of certan modifications being introduced, and somewhat delayed the progress. The vessel was launched in August, 1916, and shortly afterwards the growing need for vessels in the Navy capable of carrying aircraft resulted in the Admiralty deciding to convert the Furious into a seaplane carrier.

Considerable modifications were necessary to fit the vessel for her new purpose. As shown in Fig. 3 on the two-page Plate, the forward 18-in. gun was removed and a large hangar erected upon the forecastle of sufficient size to house 10 seaplanes. The roof of the hangar was extended to the bow of the ship, thus forming a flying-off platform 160 ft. in length, from which planes could be launched with the ship either at rest or when running at full speed. An interesting feature fitted to this flying-off deck was a portable wind screen consisting of a pallisade composed of vertical wood members arranged with batten and space alternating, and capable of being rapidly elevated or lowered. Behind this screen it was found to be possible to bring on deck, assemble and prepare for flight the seaplanes even when the vessel was running at full speed. These modifications were made and the vessel completed and commissioned in July, 1917. The exigencies of war prevented a proper speed trial being carried out, but from bearing observations it was estimated that a speed of 31¼ knots was attained with the vessel at her deep draught.

Experience with the vessel on service led to the decision to increase the capacity for carrying seaplanes. For this reason the vessel returned to the yard of her builders in November, 1917, and considerable modifications were put in hand. The remaining 18-in. gun and barbette were removed, and a second large hangar built on the after portion of the upper deck with a flying-on deck over, extending from the funnel to nearly the stern for a length of about 300 ft. The secondary armament of eleven 5·5-in. guns was reduced to 10, and the arrangement slightly modified. A considerable addition was made to the torpedo installation, 16 above water 21-in. torpedo tubes being added in the form of four triple and four single mountings installed on the upper deck. These modifications entailed considerable alterations and additions to the

ship as originally completed in July, 1917, the after tripod mast being removed, workshops and store rooms provided, lift for transporting seaplanes from the hangar to the flying deck installed, cranes and derricks for seaplanes and torpedoes fitted and additional accommodation for officers erected, boat stowage rearranged, &c. Notwithstanding their extensive character, these modifications were executed most expeditiously, and the vessel left the Tyne and entered active service in March, 1918. Figs. 1 and 2 show the vessel as finally completed.

The propelling machinery was supplied and installed by the Wallsend Slipway and Engineering Company, Limited, Wallsend-on-Tyne, acting as sub-contractors to Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited. In order to transmit the high power required it was necessary to provide four lines of shafting, each of which line is driven by its own independent set of geared turbines, of which views are given on the two-page Plate. The propelling engines and accessories are placed in four separate watertight compartments, each set being complete in itself and capable of being operated independently one of the other. Wing compartments are formed by two longitudinal bulkheads placed respectively on the port and starboard side of the centre line of the vessel, the remaining middle compartment being further divided by an athwartship bulkhead, thus forming four separate engine rooms.

Each set of turbines consists of one high-pressure and one low-pressure ahead going turbine working in series, together with one astern-going turbine, which is arranged at the exhaust end of the low-pressure ahead-going turbine. The turbines are of the Brown-Curtis type with wheel stages for all turbines, the high-pressure ahead turbine containing six wheels, of which the first wheel has two rows of blades, while the remaining wheels have each one row of blades. The low-pressure ahead turbine consists of nine wheels with a single row of blades to each wheel. The astern-going turbine has two wheels only, but each of these wheels is provided with three rows of blades. Provision is made on the low-pressure turbines, at one of the intermediate stages, to admit exhaust steam from the auxiliary machinery, which is in accordance with the usual practice in Admiralty vessels. An adjusting block of the Michel oil-film type is fitted at the forward end of the high-pressure and low-pressure turbines.

The admission of steam to the high-pressure ahead turbines is under effective control by arranging the first stage nozzles in groups and providing each of these groups of nozzles with its own controlling valve. Economy in consumption of steam is thus obtained, as the number of nozzles open at any one time can be regulated and a full pressure head of steam kept under a wide variation in load. Up to the present time this arrangement for preserving reasonable economy has shown itself sufficient, although provision was made for the installation of a cruising turbine should such a course be considered necessary.

The rotating parts of the turbines consisting of the rotor shaft and wheels are made from ingot steel forgings, while the blading is of phosphor-bronze material. The turbine casings consisting of top and bottom halves are made of cast-iron, the diaphragms for the various stages being of cast-iron with nozzle vanes of nickel steel. The bearing bushes for the rotor shafts are made in gun-metal lined with white metal. The whole of the bearings for the rotor shafts are arranged to work under a system of forced lubrication with oil baffles fitted at the ends of the bearings.

The turbines transmit their power to the gearing through flexible couplings of the claw and sleeve type, which are made entirely from forged material. The pinions which are driven by the turbines as shown in Fig. 5 are placed one on each side of the large gear wheel, the shaft of which is directly connected to the line of propeller shafts. The gearing is of the double helical type, with each section of the wheel rim placed sufficient distance apart to allow of central bearings being fitted to the pinion shafts. The gear wheel itself is of the built-up type, the rims being provided with flanges to which are bolted the side plates, these in turn being bolted at their centres to the flanges of the wheel boss, this being in two sections. Distance-pieces are placed between the sections of the wheel rim and boss and bolted thereto. The rims, shafts and bosses of the gear wheels are made from ingot steel forgings, while the pinions which are forged solid with their shafts are of nickel steel. The gear cases, which are iron castings, are made in upper and lower sections, divided in the plane of the axes of shafts of the pinion and main wheel. The bearing bushes for the pinion and wheel shafts are made in gun-metal lined with white metal, as is usual with Admiralty practice.

As the satisfactory working of the gearing depended upon its efficient lubrication, there are fitted to attain this end oil sprayers to the gear cases in such positions that they will spray oil upon the engaging teeth of the pinions and wheels, both in the ahead and astern-going direction. Sight holes having easily removable doors are fitted for the examination of the sprayer nozzles. The bearings for the pinion shafts and gear-wheel shafts also work under forced lubrication.

The proportions of the gearing are such that with revolutions of the high and low-pressure turbines, respectively 2,580 and 1,380 per minute, the corresponding revolutions of the propeller shafting are 330 per minute when developing 94,000 shaft horse-power.

The turning gear, which is placed in close proximity to the main propelling gear cases, has the large worm-turning wheel placed direct upon the main line of shafting. The gear is operated as required by an electric motor through an Hans-Renold patent chain.

For the examination and overhaul of the turbine rotors, blading and gear wheels, which necessitates the removal of the upper portions of the turbine casings and gear cases together with the exhaust bends between the low-pressure turbines and condenser, special lifting appliances have been supplied. These consist generally of lifting blocks, hand operated, and arranged where required to traverse upon runways formed of rolled sectional bars, these being attached to the deck beams of the vessel. When lifting the turbine casings and rotors, guide pillars and brackets are provided to prevent damage taking place to the blading. The condenser doors can also be handled in a manner similar to that indicated above.

The controlling of the turbines under manœuvring conditions is conducted entirely from the middle engine rooms, pipe connections being led through the longitudinal bulkheads to the turbines in the wing engine rooms. The manœuvring valves are grouped adjacent to the starting platforms, with the spindles led down to handwheels placed at a convenient height for working. The two sets of turbines on the port side of the vessel are operated from the aft middle engine-room, and those on the starboard side from the forward middle engine-room.

To provide for the expansion of the main steam pipe lines within the engine rooms the ball type of expansion connection is generally adopted, while in the main steam lines in the boiler rooms a combination of bends of large radius and ball expansion connections are fitted.

The thrust blocks are of the now well-known Michel oil-film type, each with one large single collar, 40 in. diameter. The main castings comprising the top and bottom portions of the thrust block are of cast steel, while the spherical portions and the thrust pads are of gun-metal, these pads being faced with white metal. The diameter of the thrust shaft in its bearings is 15 in. These shafts which have been kept as short as possible are hollow bored with a 9-in. hole. The intermediate shafting is 15½ in. diameter in the plain part being hollow bored with a 10-in. hole. Supporting bearings for these shafts are situated at frequent intervals, these bearings working under forced lubrication, with glands fitted at the ends of the bearings to prevent waste. The stern tube shafts are increased in diameter where passing through the stern tubes. A loose coupling is fitted inboard at the forward end of these shafts, while the aft end, outboard, has a solid coupling which joins a similar coupling on the propeller shafts. The aft ends of the propeller shafts work in bearings carried by the aft stern brackets forming part of the vessels' structure, while an outboard bearing, situated about midway between the stern tubes and the aft stern bracket, is also provided. The outboard bearings, together with the stern tube bearings, are of the *lignum vitæ* lined type, gun-metal liners being fitted on the shafts in way of the bearings. The whole of the thrust, intermediate, stern tube and propeller shafts are made from ingot steel forgings to pass Admiralty tests and requirements. The shafts are hollow bored in all cases.

The main condensers are of the type now usually adopted for Admiralty vessels, one for each set of turbine machinery. In the wing engine rooms they are placed immediately forward of the low-pressure turbines, while in the middle engine rooms they are placed alongside the turbines. Connection between the low-pressure turbines and condensers is by means of large exhaust bends, built up of steel plates and angle bars. The condenser bodies are built up of steel plates and angle bars, while the tubes and tubeplates are of material of the usual Admiralty mixture, the condenser ends and doors are of cast-iron. The condensing plant is capable of maintaining a vacuum of 28 in. when the barometer is standing at 30 in., and with a sea water temperautre of 55 deg. F. In connection with the feed-water system there are fitted four direct-contact feed-water heaters designed to utilise exhaust steam, together with eight grease extractors of the gravitation type, there being one feed heater and two grease extractors in each engine-room, which are arranged in conjunction with the feed tanks. The feed water is delivered by the air pumps through the feed heaters into the grease extractors, from where it passes into the feed tanks, the feed pumps drawing it therefrom and discharging it to the boilers. The feed pumps are of the direct-acting vertical type of which there are six pairs main and three pairs auxiliary, each pair consisting of two single pumps forming one unit. The feed pumps are placed in the boiler rooms.

In connection with the forced lubrication system each of the four engine rooms is provided with its own pumps and oil coolers. The service for the bearings is separate from that of the gearing. In each engine-room for the bearing service there are fitted two direct-acting vertical pumps together with an oil cooler, and for spraying of oil on the teeth of the gear wheels, there is fitted one pump of similar type, together with an oil cooler of corresponding size. For circulating water through the oil coolers, four vertical single-cylinder direct-acting pumps are fitted, one in each engine-room. Oil drain tanks placed at a low level are arranged in conjunction with the lubrication system. The auxiliary machinery generally follows the latest Admiralty practice.

The boilers are of the Yarrow small-tube type, as adopted in light cruisers. They are arranged for burning oil fuel only under the closed stokehold system of forced draught. The working pressure is 235 lb. per square inch. There are 18 boilers in all, of similar size, and they are arranged in three boiler rooms with central stokeholds. The uptakes from all the boilers are grouped and led up into one large oval chimney. The details of the construction of the boiler casings, uptakes and chimney are generally those which obtain in Admiralty light cruiser work. The oil-burning installation is of the usual Admiralty type in which the oil is sprayed under a direct pressure head. For supplying the oil to the sprayers there are nine pumps in all, of the vertical direct-acting type, the pump ends being of cast-iron fitted with cast-iron liners. The oil from the pumps is delivered through the cold oil fuel filters into the oil heaters, which are placed in the wings of the boiler rooms. After leaving the heaters the oil passes through the hot oil fuel filters to the distributing valves attached to the boiler fronts. The air cones and sprayers are of the usual design for this class of work. One hand oil-fuel pump of the three-throw crank type for use when raising steam is fitted in each boiler room. The air supply to the boiler rooms is provided by an installation of 18 engine-driven fans.

THE CALIBRATION FUNCTION IN INDICATING INSTRUMENTS.

On the Relation of the Apparent to the Virtual Calibration Function in Indicating Instruments.

By Frederick J. Schlink.*

The existence of the hysteresis phenomenon in the operation of indicating measuring instruments, as already set forth in some detail in earlier papers by the present author,† involves difficulties in the matter of specifying the sensitivity or its reciprocal, the scale value, of such instruments, in that the apparent or observed sensitivity becomes clearly a function of the previous operational history of the instrument. For the sake of clarity and explicitness, it is desirable to refer this multiform function to some basic or intrinsic property or characteristic function of the instrument. This, fortunately, is found in the performance which it would exhibit were it free from all frictional resistances and from certain mechanical imperfections of a nature later to be specified.

Such an instrument, which we might call the ideal instrument of its type, would produce a perfectly definite and reproducible calibration curve, and its resilience (or efficiency in restoration of stored energy) would be exactly unity. If we consider any given measuring instrument so idealised, the calibration curve it would afford may be called the ideal or "virtual" calibration curve, and the slope of that curve the "virtual" sensitivity. It is to this curve that we shall refer, for the purposes of analysis, the actual cyclic calibration curve of the real and hence imperfect instrument. Even the actual or loop-form curve must be obtained under definite, specified conditions, for, as has been shown heretofore, calibrations taken without first setting up a cycle state in a constant environment, and without providing for slow, aperiodic approach of the indicator to its rest point, are not in themselves reproducible, and hence of no definite value

* Associate Physicist, United States Bureau of Standards.

† Variance of Measuring Instruments and Its Relation to Accuracy and Sensitivity, Scientific Paper No. 328 of the Bureau of Standards; The Determinateness of the Hysteresis of Indicating Instruments, Journal of the Washington Academy of Sciences, vol. ix., No. 2, January 19, 1919; The Concept of Resilience with Respect to Indicating Instruments, Journal of the Franklin Institute, February, 1919.

for our purposes unless analysed by inconvenient and imperfect statistical methods.

The ideal or virtual calibration curve can always be computed from a knowledge of the dimensional and other constants of a given instrument, and of the applied magnitude-deflection relations of the elementary components of the instrument; but, as a rule, it is difficult, if not impossible, to determine such constants with the precision required to derive the calibration curve exactly enough for practical use of the instrument. Fortunately, the desired function can usually be quite accurately obtained by direct methods, as a result of an actual performance calibration of the composite mechanism. As is well known, the subjection of an instrument to vibration of suitable amplitude in the stabilising gear, the function of which is to constrain the platform to movement in parallel planes. This latter curve exhibits a greatly diminished included area, and hence a correspondingly diminished variance of indication, while its greatest width tends towards its middle, rather than its upper end, on account of the decreased dependence of the total frictional resistance upon the load applied to the platform of the scale.)

The dotted line, flanked by crosses, gives the calibration to which the instrument tended when subject during its calibration to strong vibration. The crosses indicate the convergence of the high variance, corresponding to the unvibrated condition, toward a minimal and, perhaps, negligible variance. In every case it

In this connection, it may be said that while a very considerable amount of energy is required in the tapping practically to eliminate the hysteretic lag, the very slightest tapping is, nevertheless, able to *reduce* this lag to a noticeable extent. For example, the same scale which required a heavy blow, as has been indicated above, to eliminate nearly all the hysteretic lag, would respond by a slight non-reverting movement of the pointer, to the gentlest sort of jarring of the table, such as a tap with the finger tip near by, or a footstep on the floor of the room. Such slight vibration would effect an irreversible movement of the pointer of appreciable amount, of the order of one-half the minimum graduation of $\frac{1}{4}$ oz. This is a quite reasonable result, since when a considerable displacement of

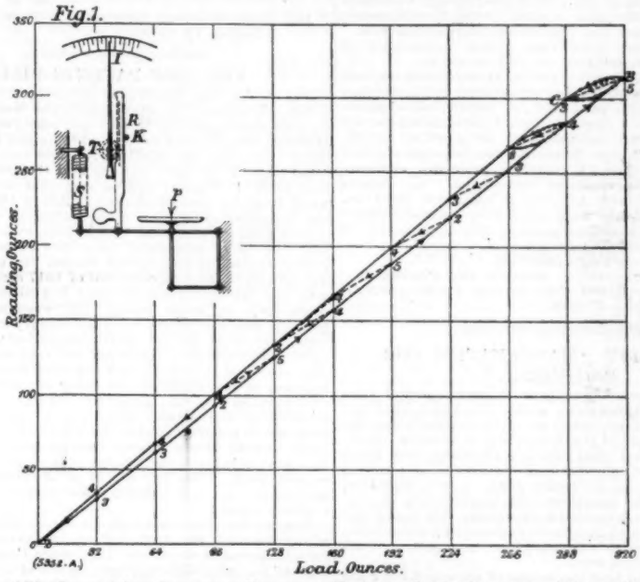
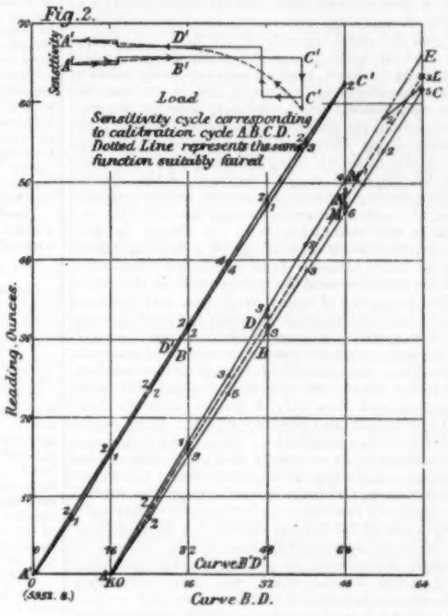
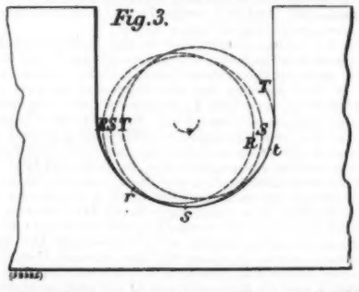
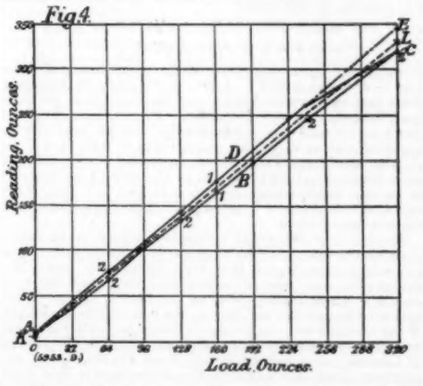


FIG. 1. This figure, taken from an earlier paper, illustrates clearly the nature of the cyclic calibration function of a common and typical indicating instrument (a low-grade, spring-controlled, automatic weighing scale), shown diagrammatically at the left. The indication function for short cycles is of analogous form to that obtained in magnetic induction, and the secondary loops are asymptotic to, and contained within, that corresponding to full-range operation.







and orientation greatly enhances the reproducibility of its reading over that corresponding to ordinary acyclic, unregularised operation. It will appear from what follows that such treatment, when feasible of accomplishment, gives a calibration result closely approximating the virtual calibration curve desired.

In Fig. 2, the solid lines ABCD present the results of the cyclic calibration of a spring-controlled weighing scale, carried out in the manner described in detail in the second reference of note †, page 204. The instrument used is a different individual from that of the paper referred to, but its type is the same, and its operating characteristics similar.* To obtain this curve, the instrument, after being operated a number of times over the full-capacity cycle, 0–64 oz., was calibrated by being subjected to a series of loads increasing by 8 oz. increments up to 64 oz. and back to zero, each load being slowly applied or removed, so that the pointer in no case overshot its rest point—jarring or vibration during the run being carefully precluded. The result is the usual one for an instrument having a complex linkwork and high frictional resistance. (The curve at the left, $A^1 B^1 C^1 D^1$ is a calibration under the same conditions except that the hysteresis is diminished by application of the load to that point of the platform making a minimum the effect of friction

* Except that it was free from transient after-effect or drift—which appeared to a small extent in the scale used in the work of the previous paper.

was found that when the jarring was repeated often and hard enough, the calibration points approaching from opposite phases of the cycle tended to become coincident, and, in the case under observation, were in fact coincident within the errors of observation (±0·1 oz.). It may be said that the amount of jarring required to obtain this result was surprisingly large; the scale itself (weighing about 26 oz.) was set upon the corner of an ordinary office table, and the requisite jarring carried out by striking the table as strongly as possible with the fist, at a point very near to the base of the scale.

The attainment of the desired end of virtually frictionless operation of the scale during the application of the jolting was readily checked by observing the manner of movement of the indicator, which—in the regions of MN and M^1N of the figure—when jarred, moved, if at all, only toward the centre of the loop, while when at the terminal point N, the pointer oscillated under jarring indifferently toward either M or M^1. This gave an indication of the end-point of the reduced variance, which was quite sharp, and at the same time afforded assurance that the zones MN and M^1N could not in fact overlap.

the parts in one direction has occurred, the frictional reactions in the bearings, together with the restoring forces in the instrument, are in equilibrium with the motive force (or in the case of a scale, the weight of the load), while at the same time the frictional resistance has reached substantially its superior *limiting* value, so that the slightest change in the configuration, as occasioned by jarring or vibration, acts upon a system which is unstable for small displacements, but which becomes more stable, however, as the bearings revert to their basic positions, wherein the aggregate frictional resistance falls well below the limiting or maximum value, and relative sliding motion no longer impends. Experiment shows this to be the case, because after the indicator has once taken up a slight movement due to the tapping, it has become much less responsive to such tapping, and more and more energy is required to bring about change of the rest point.

The virtual single-valued calibration curve, obtained as described, bears a peculiar and interesting relationship to the loop corresponding to the cyclic calibration; it lies below the latter at the lower or zero end of the calibration and above it at the upper end. The reason for this is not far to seek, but in noting it we obtain an illuminating verification of the operation of backlash or slack-bearing effects described in the first reference of note †, page 204. Let it be recalled that the effect of vibration is primarily to reduce the frictional resistances by causing journals and bearings, gears and pinions, &c., to pass momentarily out of physical contact, and, secondarily, to permit them so to acquire the ideal, or most stable, configuration corresponding to the resultant of the existing force system actuating the mechanism toward a definite equilibrium configuration. Thus we see that Fig. 3 can be considered to represent, in an exaggerated manner, the condition of a typical instrument journal and bearing. In the acyclic state the journal may lie, as the result of previous accidental movements, either in locus R, S or T. In the cyclic state, that is, after the instrument has been operated a number of times over the range of L_0 to L_1, the position R corresponds to region of the hysteresis loop near A, position S to region B and position T to region C (assuming clockwise movement of the journal to correspond to increase of reading of the instrument).

As the load is applied, and the indication increases correspondingly, the journal in question in part rolls

and in part slides* through the position S to position T, and as the load is removed, the reverse cycle takes place. The displacements of the several positions of the journal from the nominal position of the centre of relative motion of the journal and bearing are reproduced, usually greatly magnified, in the changing deviation of the cyclic calibration loop from the virtual calibration line. We thus observe the second—and perhaps the more important—effect of the operation of friction. The first effect tends toward an equal displacement of each branch of the cyclic calibration loop from the virtual calibration line, the second imposes a change or systematic variation in that displacement. The result obtained in any given instrument depends upon the relative magnitudes of these effects.

Fig. 4 presents the same general characteristics as does Fig. 2, applying, however, to another scale having five times the rated capacity of the first. It is to be noted that in both figures the virtual† calibration curve tends to have a slope approximately midway between the slopes of the upper and lower branches of the cyclic loop, which justifies, only as a rough approximation, the common assumption that the mean indication of an instrument in practice, at a given value of the quantity being measured, is well represented by the mean of the intercepts of the upgoing and downcoming calibrations on the proper ordinate. This is, of course, distinctly not the case over the end regions of the calibration loop. It should be said, moreover, that such calibrations of indicating instruments as have hitherto been commonly conducted, lacked the definiteness of the type specified in the second and third references of note†, page 204, and reviewed herein, in that ordinarily no attempt has been made to assure slow aperiodic movement of the pointer throughout. In fact, pressure gauges, voltmeters, aneroids, and the like, are commonly tapped before reading, and it is but rarely that any sort of cyclic calibration is employed, and then only, I believe, with the first-named instrument, and possibly with the steam-engine indicator.‡ It is important to note in this connection that the tapping, as ordinarily and practically carried out, results in a reading which, while nearer the virtual calibration curve, and hence in a sense more "accurate," is not nearly so conducive to ultimate accuracy as is the new type of calibration carried out in a definite, cyclic manner, aperiodically and in the absence of mechanical disturbance or jarring, in that the latter method gives results which are more accurately *reproducible*, in laboratory practice at least.§

The author is happy to acknowledge his indebtedness in consultation and suggestions to his colleague, Mr. Harry M. Roeser, of the Bureau of Standards. Mr. Roeser has recently carried out a considerable amount of experimental work, relative to another phase of the action of vibration in diminishing instrumental variance, and has obtained valuable data showing the actual diminution effected by vibration, in the energy consumption of an instrument in the cyclic state, as indicated by the diminished area of the hysteresis loop. The instruments employed were subjected during calibration to strong mechanical vibrations, both with the friction corresponding to the normal operating condition and with the interposition of an artificially-applied external frictional resistance of considerable magnitude.

* See the first reference in the footnote†, on page 204 *ante*. In a dynamo-meter, at least, of this type, position R may be decidedly "lower" than position T with respect to the base V of the bearing, because of the lower normal pressure obtaining between the surfaces in contact. It may be that at such low unit pressures as obtain in the bearings of such instruments, the coefficient of friction will rise appreciably with the load, due possibly to the change in the actual order of contact which take place as minute protuberances in the surfaces are depressed toward the general surface. The greater value of the distance CL as compared with AK in Figs. 2 and 4, seems to suggest the above hypothesis.

† In the foregoing, the use of the term "normal sensitivity," or "normal calibration," has been avoided, on account of the restricted application of the term normal in magnetic technology, wherein "normal induction" refers not to a frictionless or hysteresis-less function, but to a *usual* or *commonly encountered* type of induction, probably quite remote in its locus from the magnetization curve which would be obtained were hysteresis eliminated, as by sufficient jarring, if that be possible. The term virtual has been used in the sense found in "virtual image," of something which does not necessarily exist in fact, but does in essence or effect.

‡ For an important exception to this practice, see Stine: Hysteresis Errors of Electricity Meters Containing Soft Iron Armatures, *Elec. World*, 1899, vol. xxxiii., page 200. Professor Stine took care to avoid overshooting of readings, as well as mechanical vibration or jarring of the instrument, as he feared the effect of these on the magnitude and reproducibility of the magnetic hysteresis of the instrument—not in their relation to the mechanical hysteresis, which was not under observation, and probably not appreciably involved in his experiments.

§ This conclusion is of practical significance, of course, only when the hysteresis error is of such magnitude as not to be negligible in the ordinary, unregularised use of the instrument. In the case of the best electrical indicating instruments, the hysteretic error is very small, having about the same magnitude as the error of estimation in reading. In such cases the advantages to be gained by subjecting the instrument to a special *régime* in use or calibration, would probably not warrant the trouble involved. Unfortunately electrical indicating instruments are almost unique in the possession of this highly-desirable characteristic.

SOME DEVELOPMENTS IN AIRCRAFT DESIGN AND APPLICATION DURING THE WAR.

To the Editor of Engineering.

Sir,—We are authorised by the Right Hon. Lord Weir of Eastwood to ask if you will be good enough to correct a date quoted in his paper entitled "Some Developments in Aircraft Design and Application during the War," given before the North-East Coast Institution of Engineers and Shipbuilders on July 10, 1919.

The date of 1882 given for M. Drzewiecki's original treatment of propeller design should read 1892. In that year M. Drzewiecki presented two papers, one entitled "Memoire sur une methode pour la determination des element mecanique helicoidaux," on April 4, to the French Academie des Sciences, and another entitled "Une methode pour la determination des elements mecaniques des propulseurs helicoidaux," on December 15, to the French Association Technique Maritime.

The date 1882 has been quoted by several English writers, and we therefore welcome this opportunity of correcting a prevalent misquotation.

Yours faithfully,

Ogilvie and Partners.

Gwydir Chambers, 104, High Holborn, London, W.C. 1,
August 7, 1919.

UNIVERSITY "MATHEMATICS FOR ENGINEERS."

Sir,—Two issues of your journal have appeared since you printed my first letter under the above heading; and it seems that no one is going to dispute either my particular instance of the University of London, or my general contention that British engineers are being handicapped through the bad mathematical teaching that they get from university men. I will, therefore, now deal with the prevalent misunderstanding in connection with the hyperbolic functions, this being one of the cases in which American engineers (and doubtless those of other foreign countries) have been getting much better teaching than ours.

It is well known that the values of sin v and cos v are given by the convergent series $v - v^3/3! + v^5/5! - \ldots$ and $1 - v^2/2! + v^4/4! - \ldots$. If we here change each minus to a plus, we get what are termed the *hyperbolic sine* and *hyperbolic cosine* of v; and these are distinguished by the addition of *h* to the symbols for the other sines and cosines, in this way:—

$$\sinh v = v + v^3/3! + v^5/5! + \ldots$$

$$\cosh v = 1 + v^2/2! + v^4/4! + \ldots$$

From these equations it is easily seen that $\sinh v = \frac{1}{2}(e^v - e^{-v})$ and $\cosh v = \frac{1}{2}(e^v + e^{-v})$; and, on squaring these last two expressions, it will be found that we have the formula $\sinh^2 v = \cosh^2 v - 1$, corresponding to $\sin^2 v = 1 - \cos^2 v$. Consequently, for all positive or negative values of v, the point (cosh v, sinh v) will be on the semi-hyperbola whose equation is $y^2 = x^2 - 1$ with positive values of x, just as the point (cos v, sin v) is on the circle whose equation is $y^2 = 1 - x^2$. This explains why the new functions are called *hyperbolic*, and the old ones *circular*.

Some of our university professors appear to be fairly clear on the matter so far as it has been dealt with in the preceding paragraph. But they frequently leave the student to make the erroneous inference that the v in sinh v is numerically equal to the length of the corresponding hyperbolic arc, just as the v in sin v is the length of the circular arc; and some of them (including at least one lecturer in engineering mathematics to the University of London, as is proved by the book referred to in my previous letter) distinctly tell the students that this is so. He would accordingly consult a table of hyperbolic functions and say that the length of the hyperbolic arc is 1·41 when the hyperbolic cosine is 2·17; and for this very bad answer (not even correct to the first figure) he would presumably get full marks from his university. Yet the incorrectness of all such answers is easily proved; for a reference to the above equations will show that (except when $v = 0$) sinh v is always numerically greater than v, whereas it obviously cannot be numerically so great as the corresponding arc.

In a book written about twelve years ago by a Professor of mathematics at an American university, I find a perfectly correct explanation of what the v in sinh v represents in connection with the hyperbola; and this may be put in a somewhat simplified form as follows:—

Make a rough sketch of the semi-hyperbola whose equation is $y^2 = x^2 - 1$ with positive values of x; and from any point R on the curve (a point whose co-ordinates are $x = \cosh v$ and $y = \sinh v$) draw the straight line R T meeting the Y axis at right angles. If A is the point at which the curve crosses the X axis, the area O A R T will evidently be given by the integral of $x \,.\, d\,y$ from $y = 0$ to $y = \sinh v$; and as $x = \sqrt{1 + y^2}$, the value of this integral will be found by putting sinh v for y in $\frac{1}{2}\,y\,\sqrt{1 + y^2} + \frac{1}{2}(\sinh^{-1} y)$. (The direct integration is not easy; but anyone who understands the simplest elements of the infinitesimal calculus can prove that the above result is correct, by differentiating the last expression with respect to y and noticing that this gives $\sqrt{1 + y^2}$). The area O A R T is therefore $\frac{1}{2}(\sinh v \times \cosh v) + \frac{1}{2}v$; and as $\frac{1}{2}(\sinh v \times \cosh v)$ is the area of the triangle O R T, it will be seen that $\frac{1}{2}v$ must be the area of the hyperbolic sector O A R.

We thus arrive at the conclusion that the v in any hyperbolic function such as sinh v, is numerically equal to twice the area of the corresponding hyperbolic sector; and we see that this fact can be proved to any student who has a slight knowledge of the infinitesimal calculus. It may sometimes be found desirable to talk about hyperbolic functions to students who have not the necessary knowledge for understanding the proof; but such students should, of course, be told the fact, instead of being told, or left to infer, that the v is numerically equal to the length of the hyperbolic arc.

Yours respectfully,

W. F. Dunton.

165, Tamworth-road, Newcastle-on-Tyne,
August 11, 1919.

THE NEW PATENTS BILL.

To the Editor of Engineering.

Sir,—This new Bill upon which you freely comment in your leading article of 1st inst., may (we are told in the Bill) now be cited as the "Patents and Designs Act, 1919," and that the principal Act and this Act may be cited together as the "Patents and Designs Acts, 1907 and 1919." ! Thus it will be seen that we cannot get away from the present obnoxious Act of 1907, in which are incorporated all the worst points of the German patent system, and from which were excluded all the best and most democratic principles embodied in the patent system of the United States. In exposing the absurdities of the proposed Bill of 1917 some two years ago, and which resulted in this Bill ultimately being withdrawn, we little thought that even a worse proposition would be foisted upon the country at the present time, after what the influential deputation which waited upon the President of the Board of Trade some time last year were led to expect, and one may now almost feel hopeless of any improvement being effected in the way of invention and the protection of inventors in this country by the present Government. As regards the proposal to lengthen the life of British patents to sixteen years instead of the present fourteen years, that is, as you truly point out, right so far as it goes, but why only sixteen years, when the life of an American patent is seventeen years, and that of a Canadian patent is actually eighteen years ?

I notice that the only speaker in the House of Commons who supported the new Bill on its introduction was (of all persons in the world) Sir George Croydon Marks, M.P. (C.L.), who (although forming one of the deputation to the Board of Trade strongly urging reform) actually is reported to have stated that the new Bill would be the cheapest patent law in the world, and that no other country, for a fee of 5*l.*, guarantees an inventor protection for six years; he further is reported to have said that the corresponding fee in Germany was 40*l.*, in France 23*l.*, and in America 7*l.* 7*s.*, which to my mind was surely most misleading.

Did Sir George forget that in the United States the said fee of 7*l.* is the total Government charge for seventeen years, while by the proposed new Bill the corresponding fees in this country for the suggested sixteen years would still be over 100*l.* ? Apparently also the farcical so-called system of "searching" here is to be continued, and the ridiculous practice of endorsing a patent with the words "Licences of Right" (as *only* prevalent in Canada, and as was suggested in the proposed 1917 Bill) is to be embodied in the new Bill. As an old patent law reformer, inventor and patentee, I am at one with yourself (when you point out) that: (1) The new Bill is bound to be subject to severe hostile criticism; (2) the Government have treated with contumely the representations made to them by the Special Committee convened by the Institution of Mechanical Engineers last October; and (3) that only one of the said committee's suggestions has been partly met. I am in entire disagreement with Sir George Croydon Marks' welcome of the Bill as one that will encourage the poor inventor and give him or any other inventor "protection"—God save the word. I believe, indeed, it will do the very opposite, and at the same time that it will tend greatly to increase patent litigation. In order to show that I am not quite alone in my belief, I may be allowed to quote a few words from a letter I have just received on the subject from a well-known chartered patent agent of repute. This progressive gentleman writes:—

"To tell the truth I am quite unable at present to devote time to peruse such trash as a Government Bill. You know my views on our patent legislation, and I feel that nothing anyone can say will make any difference. I fail to see what benefits worth while anyone really gets under the Bill.

"Any how, what one gets is but a small fraction of what one ought to get. At present the Patent Office does precious little for the money. Either less money should be paid or the Patent Office should do something for patentees."

As regards the hardships which patentees have suffered during the five years of war in being absolutely prohibited by war regulations from working many of their inventions while still having to keep paying their annual and increasing renewal fees to keep their patents alive; I should say, in common honesty, it ought not only to be the duty but the privilege of the Government to see that these lost five years are automatically added to the term of such patents. Surely just at the present time, with reconstruction of the industries of the country in hand, when, according to the Chancellor of the Exchequer we may possibly be on the way to national bankruptcy,

and, the coming stern competition of our only real competitor (the United States) before us, we in this country are entitled to be given "equality of opportunity" at least with our American cousins in having an up-to-date democratic patent system on American lines or the encouragement and protection of inventors and an invention, instead of being placed (as the passing of this Bill would place us) in a back seat in the race for the coming world's business?

It is an open secret known to practical and business men with knowledge of both countries that the only comparative progressive difference between the two countries is that in the case of the United States, inventive genius is fostered and encouraged by the American Government principally because of its wonderful and successful patent system, while in Great Britain with its antediluvian patent arrangements and exploded dogmas and shibboleths, invention is admittedly discouraged by the British Government and taxed to the utmost limit for revenue, being "cribbed, cabined and confined," with the result known to the whole civilised world.

One thing the Bill does, and that is it makes the business of patent agents into a profession again, following a German precedent, and enables every registered patent agent to call himself a "doctor"; the Bill also makes it penal for anyone but a duly registered home agent to do patent agency work, which provision may be good or bad for inventors or the general public. Since this letter was penned I have read with pleasure your article on "Moratorium for Patents," in ENGINEERING of 8th inst., with which it will be seen from the foregoing I am in full agreement, and it is to be hoped that the Government will introduce a separate Bill dealing with this important subject; I also see that last night the new Bill actually passed its third reading, but, notwithstanding, let us hope that some drastic change will still be made before this retrograde legislation actually becomes law. Meanwhile one can only enter one's public protest as you and I have done against this abortion of a Bill as being entirely inimical towards the best interests of invention and the future progressive engineering business of our country.

Yours, &c.,
JAMES KEITH.

"Dunottar," 17, Kidderpore-avenue, Hampstead, London, N.W. 3, August 8, 1919.

"SCIENTIFIC CONTROL OF STEAM BOILERS."

TO THE EDITOR OF ENGINEERING.

SIR,—Along with your issue of ENGINEERING for the 25th ult. you published details of Mr. Brownlie's now historical test of 100 typical colliery boiler plants and the averages for 1,000 boilers, the tests reported in ENGINEERING, July, 1918.

In view of the present high price of coal and boiler-making material I feel justified in bringing to your notice facts relative to the Yorkshire boiler, which I am sure will be appreciated by the majority of your readers, as they not only indicate a direct coal saving of many million tons per year, but also a saving of approximately 5 tons of steel plate per boiler produced and the coal required in its making.

Job No. 1 in Mr. Brownlie's particulars sheet gives details of an 8-hours test of four Lancashire boilers, 30 ft. long by 9 ft. 6 in. diameter, and one 30 ft. by 9 ft., and, as this is the best submitted by him, I give below his figures for the five boilers mentioned along with the record of four Yorkshire boilers, 24 ft. by 9 ft. 4 in. The total hourly coal consumption of the five Lancashire boilers was 5,824 lb.; weight of water evaporated per hour from and at 212 deg. 55,444 lb., which equals 9.5 lb. per pound of coal burned; temperature of gases leaving economiser 412 deg.; overall efficiency, 71·84 per cent.

The four 24-ft. by 9-ft. 4 in. Yorkshires, fed with a similar quality of coal as the Lancashires (with the exception that it contained 17 per cent. of ash and clinker as against 11·5 per cent.) consumed 6,048 lb. per hour and gave an equivalent evaporation from and at 212 deg. of 61,053 lb. per hour, equal to 10·08 lb. per pound of coal burned; terminal temperature of gases 352 deg.; overall efficiency, 78 per cent.

The weight of the five Lancashire boilers is 182 tons, floor space occupied 2,680 sq. ft., evaporation per hour per ton of boiler plate used 304 lb., evaporation per square foot of floor space occupied 20 lb. The weight of the four Yorkshire boilers is 121 tons, floor space occupied 1,550 sq. ft., evaporation per ton of plate 504 lb., evaporation per hour per square foot of floor space occupied 39 lb., and there is also the proportionate saving of brickwork required with the four 24-ft. Yorkshires, as against the five 30-ft. Lancashires.

Mr. Brownlie, in his particulars of the 1,000 boilers tested, gives his average size as 30-ft. by 8-ft. Lancashire boilers, grate area 38 sq. ft., hourly coal consumption 799 lb., evaporation per hour from and at 212 deg. 5,958 lb., evaporation per pound of coal 7·46 lb., boiler efficiency 56·71 per cent., overall efficiency 60·09 per cent.

In the tests of 10 Yorkshire boilers, average size 24 ft. by 8 ft. 6 in., grate area 38 sq. ft., coal burned per hour 1,378 lb., average evaporation 13,164 lb. per boiler per hour, evaporation per pound of coal burned 9·48 lb., the average efficiency of five of the boilers using economisers is 79·7 per cent.; the remainder are without economisers or superheaters, and the average boiler efficiency is 65 per cent.

Probably the chief reason why the Lancashire boiler does not give a better account of itself is due to the lack of uniformity between grate area and outlet from the furnace flues. This ratio ranges from 4 to 1 in a 7 ft. diameter boiler to 2½ to 1 in a 9 ft. 6 in. diameter boiler, the latter boiler therefore doing the same work on 2½ sq. ft. of grate as the 7 ft. diameter boiler will do on 4 sq. ft., the chimney draught being equal. As in the Yorkshire boiler the furnace flues expand from front to rear, the weight of water at the back end of the boiler is greatly reduced as compared with the Lancashire boiler, but the flue expansion also offers an increasing heating surface per foot run proportional to the decreasing temperature of the gases, uniform ebullition over the whole length of the boiler thus being secured.

The expansion of the furnace flues enables the suction of the chimney to act directly on the furnaces, and further enables a constant ratio of 1·8 to 1 between grate area and outlet to be established in all sizes of boilers, whereas in the Lancashire boiler, with grates 6 ft. long, the contracted flues act as a brake on the air supply, with the result 1·8 sq. ft. of grate in a 24-ft. Yorkshire boiler will do the same work as 3 sq. ft. will do in a 30-ft. Lancashire boiler, diameters being 8 ft. 6 in.

Experience during the last twelve years has fully justified the following: A Yorkshire boiler, 24 ft. long will do the same work for 9 cwt. of coal as a 30-ft. Lancashire boiler will do for 10 cwt., diameters being equal, or, if the two boilers are working with equal chimney draught and quality of coal, the Yorkshire will give an hourly evaporation 15 per cent. in excess of the longer boiler, but maintaining the same boiler efficiency.

Although I have contracted my letter as much as possible, I must apologise for its length.

Yours faithfully,
W. H. CASMEY.

Milnthorpe, Wakefield, August 13, 1919.

ANTI-DUMPING LEGISLATURE.

TO THE EDITOR OF ENGINEERING.

SIR,—As you say, at the end of the very interesting editorial in to-day's issue of your Journal, "Much has been written on this subject of late, but not too much . . . The matter is one for the manufacturer, the politician, the workman and the civil servant."

But what about the consumer? Surely he counts—not only in the British Empire, but all over the world: and, coming straight to the point, is it not a question of our being able to produce goods of such a quality and at such a price as will secure customers? . . .

If "Germany may resort to dumping in an attempt to re-establish her industrial position," why, in Heaven's name, cannot we resort to dumping, too?

What we must realise is that "protection of industry" in war time is more important than in peace time when the consumer, who pays, will insist on calling the tune.

Yours truly,
"COSMOPOLITE."

August 8, 1919.

THE BUILDING OF AIRSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—In reference to my communication in your last issue, several of your readers have criticised my assumption that the useful life of an airship of the rigid type is not likely to exceed an average of about five years. This is obviously a reasonable contention, if based merely on the deterioration of the envelope and engines, both of which are replaceable at a relatively insignificant cost compared with the initial cost of the airship.

In estimating the probable life of an airship, it is necessary to take into consideration the ever present possibility of serious damage being caused to the framework of the ship through a "forced landing," or even a routine landing in gusty weather. A rigid airship, owing to its fragile construction, is particularly susceptible to damage of this nature, especially if there has been any appreciable loss of buoyancy during flight. Considered from this point of view the life of an airship is so uncertain that any estimate can only be mere speculation; such a ship might "crash" on its maiden trip, under adverse weather conditions. I therefore venture to maintain that my assumed life of five years is a very liberal one under the circumstances. Yet, even if this be doubled, the cost of freight per ton is still prohibitive, all the other charges remaining the same.

It would be interesting to know what the Air Ministry intend to do with the large rigid airships, both those in being and those now building, which the Admiralty have at last decided to hand over to them, this type of aircraft having now been condemned as useless as a war weapon.

At the present moment, "blimps" are being offered for sale by the naval authorities, notwithstanding the useful work which they did during the war. The reason for this is probably that it has been established that a more efficient patrol can be maintained by towing an observation balloon at an altitude of some 3,000 ft. behind a fast cruiser or torpedo-boat destroyer, with which, incidentally, it is in direct telephonic communication. This was a common enough sight during the closing months of the war.

The conclusion to which one is irresistibly drawn is that there is, with, perhaps, the possible exception of a very limited "kite-balloon" section, no need whatever for a "lighter-than-air" branch of the Air Ministry. If the whole situation could be surveyed frankly and without prejudice by a committee composed exclusively of business men who have none but the country's interests at heart, I venture to suggest that the result would be a strong recommendation to "cut the loss" and to abolish this branch of the Ministry altogether. This could very readily be done if the Admiralty were to continue in control of such "K.Bs." as are required by the Navy (including the Coast Guard) and the War Office became responsible for those required for "spotting" for the artillery.

Such a commonsense course would have the immediate effect of releasing from the Air Service not only a large number of officials, both commissioned and civilian, but a great many officers and men of all ranks, for that creative work which is the country's safeguard. Incidentally, it would relieve the taxpayer and afford the Government another first-hand opportunity of setting the nation an example in economy.

Yours faithfully,
CECIL LIGHTFOOT, A.M.I.C.E.

9, Cornwall Mansions, Regent's Park, August 11, 1919.

"APPLIED OPTICS."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the review in your issue dated August 8, of "Applied Optics," and have noted the contents with the view of a possible new edition.

There is one statement in the review which I think it desirable to correct as it concerns others and is incorrect.

Near the top of the second column it is stated that "Mr. French is another member of the scientific staff of this eminent Glasgow firm and his translation of the 'Angewandten Optik,' *also published under the auspices of the same Advisory Council*," &c. The Advisory Council have had no connection whatever with the work and therefore no responsibility in the matter.

Might I also at the same time correct the first portion of the same paragraph. I am a managing director of the firm, not another member of the scientific staff.

I remain, yours faithfully,
JAMES WEIR FRENCH.

Ardoch House, Bearsden, Dumbartonshire, August 10, 1919.

"SURPLUS."—The issue No. 5, for the 1st inst., of *Surplus*, the official organ of the Surplus Government Property Disposal Board, contains a large amount of illustrated information on the factories, hutments, plant, machine tools, implements, instruments and goods of all kinds which the Government has for sale.

BRAZILIAN COAL.—According to the British Chamber of Commerce in Brazil, it is reported that experiments have recently been made by the Central Railway with briquettes composed of national coal from the Caçapava mines and American fuel. The experiments, which were carried out under strict technical requirements, gave excellent results and fully satisfied the experts who were present. It is believed that the tests made with the Caçapava coal, from mines in the State of S. Paulo situated close to the Central Railway, with which it will shortly be linked up by a branch line of 12 km., may eventually lead to a decrease of over 50 per cent. in the imports of American coal, this leading to a very appreciable economy.

NEW FRENCH CUSTOMS DUTIES.—By a French Presidential Decree, of July 8, the Customs duties leviable on a large number of manufactured goods on importation into France and Algeria, were increased. For this purpose, for each category of goods specified in the tariff, a "coefficient" or multiplier was fixed representing the relation between the values of the goods in 1913 and in 1918, according to the official valuations laid down for those years by the Permanent Commission on Customs Values. The present rates of duty are, therefore, the specific rates contained in the pre-war tariff multiplied by "the co-efficient" (varying from 1·1 to 3) attributed to the class of article concerned. A Parliamentary Return entitled "France and Algeria: Increase of Customs Duties," which has been published by the Board of Trade contains a translation of the Decree and of the Ministerial report explaining its nature and object, together with a statement showing in detail the French tariff rates of duty on the articles affected by the increased duties and the "coefficient" or multiplier established in each case. Copies of the return may be purchased at a cost of 9d. per copy (exclusive of postage), either directly or through any bookseller from the sale depots of His Majesty's Stationery Office. In ordering copies, the Reference Number "O.M.D. 273" should be quoted.

IRON AND STEEL INSTITUTE.—The autumn meeting of the Institute will be held in the House of the Institution of Civil Engineers, on Thursday and Friday, September 18 and 19, commencing on Thursday at 10.30 a.m. and on Friday at 10 a.m. The following is the list of papers that are expected to be submitted: Mr. J. H. Andrew, Mr. J. N. Greenwood and Mr. G. W. Green, 'Nickel Chrome Forgings"; Mr. W. A. Bone, Sir R. A. Hadfield, Bart., and Mr. A. Hutchinson, "Report on Fuel Economy in Steel Works" (with a Supplementary Report by Mr. H. J. Yates on "Fuel Economy in Foundry Practice"); Mr. E. D. Campbell, "Decarburisation of Steel"; Mr. J. J. Cohade, "On the Woody Structure of the Fractures of Transverse Test Pieces from Special Steels"; Mr. Cosmo Johns and Mr. L. Ennis, "Fuel Economy in German Iron and Steel Works"; Mr. R. H. Greaves, "Temper Brittleness of Nickel-Chrome Steel"; Mr. K. Honda, "Nature of the A1 Transformation and a Theory of Quenching"; Mr. K. Honda and Mr. H. Takagi, "On the Cause of Irreversibility in Nickel Steels"; Mr. N. Hudson, "Experiments with Nickel Steels"; Mr. C. A. Keller, "Synthetic Cast-Iron"; Mr. F. Rogers, "Brittleness in Nickel-Chrome and other Steels"; Mr. T. Murakami, "On the Structure of Iron-Carbon-Chromium Alloys"; Mr. J. H. Whiteley and Mr. A. F. Hallimond, "The Fluxing Action of Iron Oxides on Acid Furnace Structures."

FLETCHER'S ROLLING-BAR FURNACE GRATE.

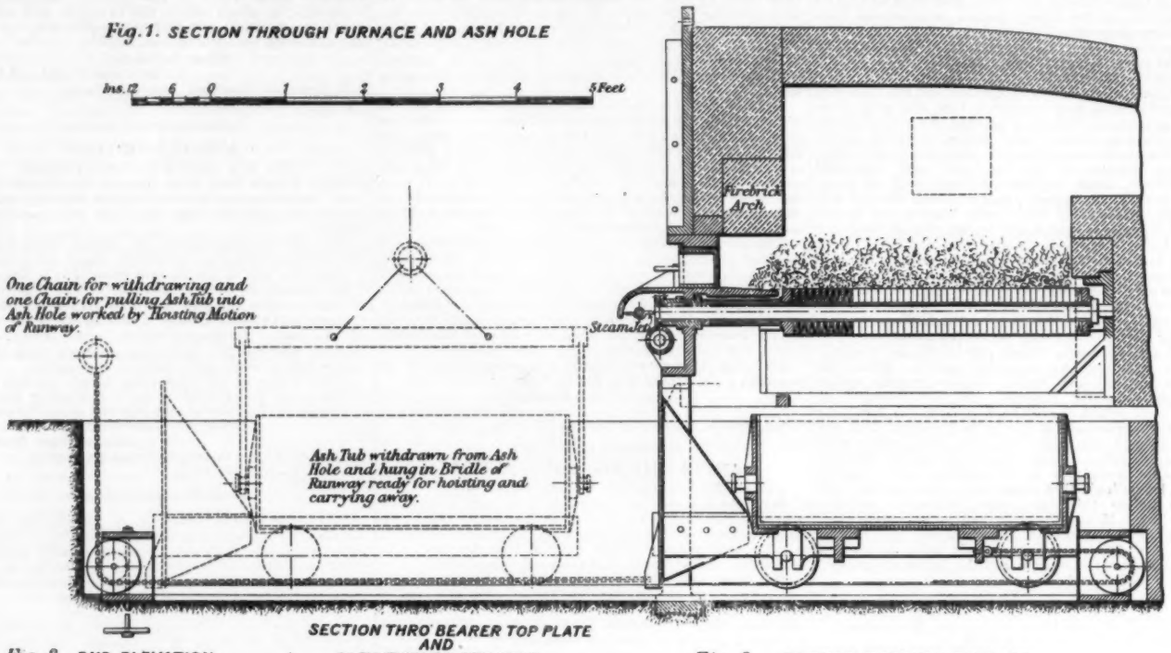
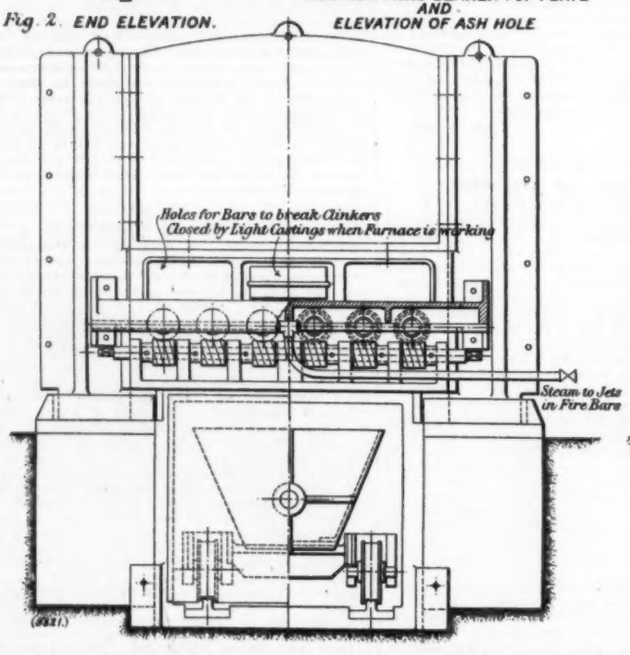
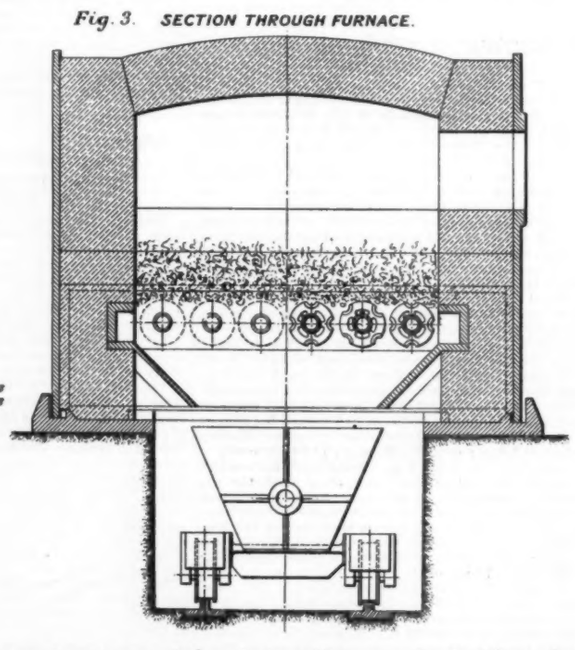


Fig. 1. SECTION THROUGH FURNACE AND ASH HOLE
Ins. 12 6 0 1 2 3 4 5 Feet
Firebrick Arch.
One Chain for withdrawing and one Chain for pulling Ash Tub into Ash Hole worked by Hoisting Motion of Runway.
Steam Jet
Ash Tub withdrawn from Ash Hole and hung in Bridle of Runway ready for hoisting and carrying away.


SECTION THRO' BEARER TOP PLATE AND ELEVATION OF ASH HOLE
Fig. 2. END ELEVATION.
Holes for Bars to break Clinkers Closed by Light Castings when Furnace is working
Steam to Jets in Fire Bars



We reproduce above drawings of a new type of furnace grate designed and patented by Mr. J. E. Fletcher, M.I.Mech.E., a metallurgical engineer of the Netherton Iron Works, Dudley. This grate is intended to obviate the difficulties experienced when burning coal containing a high percentage of ash, and it is especially suitable for application to reheating, puddling and other metallurgical furnaces using this class of fuel. In the grates usually provided with furnaces of this type, the fire-bars are plain rolled iron bars, resting on bearers, with no arrangement for ensuring correct air spacing. The bars bend and twist in working, and, often enough, become covered with adhering clinker, which blocks the air passages. In attempting to clear the grates a number of bars may be pulled out together, allowing the hot fuel to fall into the ash pit, and also permitting a large volume of cold air to enter the furnace, thereby injuring the firebrick linings and roofs. In any case a considerable quantity of unburnt fuel falls into the ash pit, so much so that, in puddling furnaces, the ashes are often sifted and washed in order to recover the breeze or "gleads." It is claimed that the above-mentioned difficulties are entirely overcome in the type of grate now under consideration, the combustible material in the fuel being completely consumed and the residue got rid of without affecting the working of the furnace.

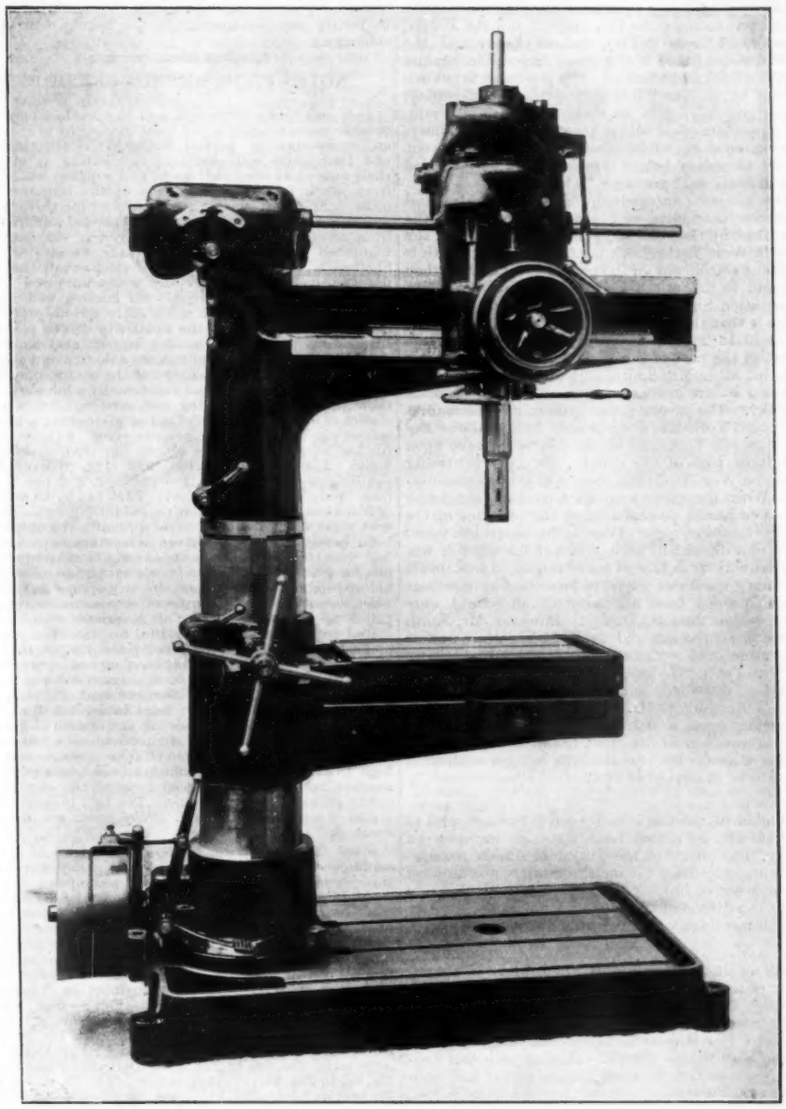
Our illustration, Fig. 1, is a longitudinal section through a Fletcher grate applied to a reheating or puddling furnace. Fig. 2 is a half-front elevation and a half section through the bearer top plate of the grate, while a transverse section through the fire-bars is given in Fig. 3. As will be seen there are, in this case, six grate bars, each of which consists of a perforated tube threaded with a large number of chilled iron discs to form a kind of roller. The shape of the discs is such that they key into each other and into the thicker discs at the ends of the series, and, as the end discs are firmly fixed on to the tube, rotation of the latter will rotate the whole of the discs together. This rotation is effected by worm gearing, operated either by hand or by power, and clearly shown in Figs. 1 and 2. The air required for combustion is forced into the ends of the tubes by steam jets, shown in Fig. 1, and passes out through the perforations and into the fuel bed and ash pit through a series of tapered nozzles formed between each pair of discs. An inspection of the cross-section, Fig. 3, will make this clear. If necessary the air can be preheated before entering the tubes by being passed through a series of ducts formed in the firebrick walls of the fire-box or furnace. In some existing furnaces the air is heated in this way to a temperature of 450 deg. F.

As will be readily understood, the ashes, which fall into the longitudinal grooves between each pair of grate bars, can easily be removed without opening the fire door, by rocking, or rotating, the bars by the worm gearing. It will also be seen, in Fig. 3, that the peripheries of the discs are notched, and the corrugations thus formed effectively break up the clinkers when the bars are rotated. Openings, normally closed by light castings, are, however, provided in the furnace front to enable any large "bats" or clinkers, that may form, to be removed. These openings, which can be seen in Figs. 1 and 2, also enable any part of the fire to be raked if necessary.

Our illustrations also show a convenient method which has been adopted for handling the ashes. As will be seen the ashes fall directly into a tub mounted

DRILLING, BORING AND TAPPING MACHINE.

CONSTRUCTED BY MESSRS. KITCHEN AND WADE, LIMITED, HALIFAX.



on a four-wheeled carriage running on rails fixed at the bottom of the ash pit. A flat plate is attached to the front of the carriage to close the ash pit when the carriage is in its normal position. By means of an arrangement of chains and pulleys, clearly shown in Fig. 1, the carriage and tub can be withdrawn from the ash pit into a pit in front of the furnace, the hoisting mechanism of an overhead runway being used for the purpose. A bridle is then attached to the ash tub, and the latter is hoisted and conveyed on the runway to the ash tip, whence it is returned empty, and replaced in the ash pit, in a few minutes. The supply of steam to the jets must, of course, be cut off, or reduced, during this operation, but otherwise the working of the furnace is not affected.

We are informed that a number of these grates have been in use for the last five years with very satisfactory results using coal containing as much as 25 per cent. of ash. The discs originally fitted are still in use, and are said to be practically as good as new. We also understand that the grate is now being applied to various types of boiler furnaces and gas producers, as well as to metallurgical furnaces.

RADIAL DRILLING, BORING AND TAPPING MACHINE.

We illustrate above a new design of radial drilling, boring and tapping machine, which has several novel and interesting features, and is now being manufactured by Messrs. Kitchen and Wade, Limited, of Willow Hall Works, Halifax. As will be seen, the machine is of the all-gear type, and one of its special features is the mounting of the gear-box at the top of the pillar within easy reach of the operator. Another unusual feature, in a machine of this size, is the employment of a double gear, which is particularly useful for boring, facing and tapping, and is located at the top of the saddle in the best position for efficient work, viz., between the reverse and the spindle. The machine is capable of drilling holes up to 1¾ in. in diameter in steel, up to 2 in. in diameter in cast-iron, and of tapping up to 1¼ in. Whitworth. It will admit work up to 4 ft. ¼ in. deep between the spindle and the baseplate, and up to 2 ft. 3 in. deep on the table.

The baseplate is a deep casting, strongly ribbed internally, and planed top and bottom. It is provided with four T slots, and also with a hole to take steady bushes for boring bars. A double sump, the two parts of which are interconnected, is formed in the baseplate, under the pillar, to collect the lubricant which drains from the slots. The pillar, which is of very rigid design and is securely bolted to the baseplate, provides deep bearings for the radial arm, and the lower portion is machined to carry the elevating table, for which no end support is needed. This table has a horizontal working surface, 27 in. long by 14½ in. wide, and a vertical face 30 in. long by 8 in. deep. As will be seen, a "vee" groove is machined in the vertical face for supporting shafts, and other cylindrical bodies, when drilling into the ends. The table is adjustable vertically by means of a handle operating through worm-gearing and rack and pinion, the total movement in this direction being 14 in. It can be firmly clamped in any position, or swung round out of the way when not required. The radial arm is of tubular construction designed to give the maximum resistance to lifting and twisting stresses. It is carried on ball bearings on the pillar and, unless obstructed by the driving belt, can be rotated through a complete circle. An efficient lock is provided to secure the arm in any position on the pillar.

As will be noticed in our illustration, the saddle has a particularly neat and compact appearance due to the fact that all its mechanism is completely enclosed. It is bedded on to the arm on flat slides, and provision is made for taking up the wear of the latter. The traverse motion is effected by means of the large hand-wheel, shown in the illustration, operating through a steel rack and pinion, the total movement possible in this direction being 26 in.; this gives a maximum radius of the drill spindle of 3 ft. 1 in. The saddle can, of course, be securely clamped in any position on the arm. The drive from the belt pulleys, seen at the base of the pillar, is transmitted through bevel gearing and a vertical shaft to a gear-box of the motor-car type mounted on top of the pillar. The gear-box, which is grease-tight, gives four changes of speed to the horizontal shaft running parallel with the radial arm, and driving the drilling spindle. These changes, with the double gear provided in the saddle, give eight spindle speeds ranging from 500 r.p.m. to 30 r.p.m. in geometrical progression. The driving wheels at the top of the spindle are mounted on a steel sleeve which runs in double bearings and drives the spindle through a long key, an arrangement which is very efficient and also greatly reduces the wear due to thrust on the gears. The spindle itself, which is 1⅝ in. in diameter, is bored to No. 4 Morse taper, and is also cottered to permit the use of boring bars, tapping attachments, &c. It is fitted with a ball thrust washer which takes the end thrust due to drilling, and twisting strains on the radial arm are reduced to a minimum by the fact that the spindle is arranged quite close to the face of the arm. The spindle runs in a hardened steel sleeve which gives a firm lateral support even when drilling in the lowest position. A spring compensating device is provided to balance the vertical movement of the spindle, which is effected by means of one of the handwheels seen in front of the saddle; the total travel of the spindle in the vertical direction is 11½ in. The spindle can be started, stopped or reversed by means of positive clutch mechanism on the saddle, and, after tapping, the tap can be quickly backed out, at a speed ratio of 4 : 1, by throwing in the single gear. Single and double gearing is also provided in the saddle, and this is controlled by the lever seen on the right-hand side. As previously mentioned, this gearing is fitted between the reverse and the spindle drive.

The feed rack is cut on the sleeve, the pinion which gears with it being of a special tough steel. The self-acting feed motion is positive, and is obtained by means of a hard steel worm which can be engaged or disengaged instantly; the thrust on the worm is taken by a ball bearing, and the worm wheel runs in an oil bath. Three rates of feed, which can be changed without stopping the spindle, are provided, and an index plate is mounted on the feed-box to show at a glance which feed is actually in use. Fine hand-feed motion, operated by the handwheel on the bottom of the saddle, is also provided.

With regard to the general construction of the machine, we may say that all driving wheels are special steel forgings, heat treated to give toughness and strength, and all driving shafts and feed shafts are of high carbon steel, which material has been found to be most suitable for withstanding the shocks and stresses present in a radial drill. The driving shafts all run in bearings bushed with hard bronze suitable for high-speed working, and all levers are of malleable iron. Careful provision has been made for lubricating all parts. If desired the machine can be arranged for driving by a constant-speed motor mounted on an extension to the baseplate and coupled directly on to the horizontal shaft. The motor used should be of from 5 h.p. to 7½ h.p., and its maximum speed about 1,000 r.p.m. When belt drive is used, the pulleys supplied are 12 in. in diameter by 3½ in. face, and the speed is 450 r.p.m.; the belt shifting device is arranged to be operated by hand lever, or by foot pedal. The machine occupies a floor space of 5 ft. 6 in. by 2 ft. 6 in., and the total height is 8 ft. 7 in.; the net weight is about 24 cwt.

City and Guilds of London Institute.—The Council of the City and Guilds of London Institute have awarded diplomas of "Associate" to 19 students in engineering and to 10 students in applied chemistry, who completed a full course of instruction at the close of the recent session.

INDUSTRIAL NOTES.

Reference to the labour situation in general was made by prominent men in speeches which were delivered in different parts of the country during the last few days.

Speaking at the University Extension summer meeting at Oxford, on Thursday, the 7th inst., Mr. J. R. Clynes said that the workers could make no more lamentable mistake than to encourage under-production. Scarcity of commodities was the opportunity of the profiteer. Scarcity might cause inconvenience to the rich, but it caused real and continued privation to the masses. If profiteering was conscious pilfering, "ca-canny" was an ignorant act which deprived many people of their real needs. Wherever "ca-canny" was practised as a design to punish the "favoured classes," it effected little loss upon them, but it inflicted the greatest loss upon the poor and those who earned low wages. It was only through the use of labour and economic resources in their highest and most efficient form that the nation could make itself equal to efficient competition with other nations and make up the arrears of war.

Mr. J. H. Thomas, M.P., general secretary of the National Union of Railwaymen, speaking at a labour demonstration at Yarmouth last Sunday, stated that the threat of downing tools every day, on every occasion and on every conceivable subject was disastrous. He had never hesitated, he added, to urge solidarity among the workers, but he found himself condemned because he had refused to subscribe to the policy of calling out the railwaymen in support of every dispute that arose. That, in his opinion, would lead both to chaos and to anarchy. It would be seen, therefore, that he had applied a very definite meaning to the word peace; he used it in its broadest and best sense. It should not be forgotten, he concluded, that the nation's coffers were empty and that they must be replenished. This could only be done by every one contributing to the best of his ability, wealth and talents. "Let us," he concluded, "band ourselves to the accomplishment of the task, regardless of social position and class interests."

Mr. William Straker, secretary of the Northumberland Miners' Association, speaking at a meeting at Tantobie last Saturday, said the Government offices were filled by lawyers, professional politicians and college professors, the most unpracticable men to have the affairs of the nation in their hands. They wanted these men removed and replaced by other men who were able to understand and direct labour.

At a special meeting of Lancashire and Cheshire miners held recently at Bolton, it was decided by an overwhelming majority that when ballot papers dealing with the Triple Alliance proposal were sent out, the members should be advised to vote against direct action.

Speaking at Nottingham on the same subject, Mr. W. Carter, M.P., a leading member of the National Federation of Miners, said he was opposed to putting into operation the sweeping powers of the Triple Alliance. He urged all workers to proceed on constitutional trade union lines with a view to being returned in sufficient numbers to form a Labour Government.

At a conference of the Triple Alliance held in London last Tuesday, it was decided to postpone the policy of direct action.

Public meetings convened by the Manchester Chamber of Commerce were held last week, and addresses were delivered in favour and against the nationalisation of the coal mines. A written vote was taken at the close, when there voted—

In favour of nationalisation	154
Against	1,828

The result was communicated to the Prime Minister by Mr. E. F. Stockton, the president of the Chamber of Commerce, who urged that the opinion of the House of Commons should be ascertained before any decision was arrived at on a question of such vital importance to the nation.

Last Friday, a conference of West and South Yorkshire coalowners and miners with the Coal Controller and the Minister of Labour was held in London, but no settlement was arrived at.

A further conference was held in Leeds last Monday, between West Yorkshire coalowners, Mr. Herbert Smith and members of the Yorkshire Miners' Association, when Mr. Smith, in answer to his request that various points of detail be discussed, was informed by the coalowners that the time had now come when they must decline further to discuss any detail point until there had been a resumption of work.

Dealing with last Friday's meeting, *The Yorkshire Post* says that both owners and men appear to be in complete agreement as to an advance of 14·3 in piece rates to meet the reduced hours of labour under the Sankey award, and to this extent Mr. Herbert Smith finds justification for committing the county to a prolonged strike with disastrous consequences to industry generally. On the other hand, the suggested settlement of 14·3 is in advance of the national formula agreed upon between the Government and the Miners' Federation of Great Britain, and on this ground the Coal Controller found it absolutely impossible for him to sanction such a settlement. The position was put in a nut-shell by a West Yorkshire owner on Saturday. "If you give Yorkshire an advance of 14·3," he said, "the immediate effect will be that the Yorkshire miners will return to work, whilst other coalfields will come out in order to obtain better terms than those conceded under the national agreement."

While the two interests in South Yorkshire find themselves in conflict with the Coal Controller, the stand taken by that official justifies the attitude of the owners in West Yorkshire, whose reply to Mr. Smith is that in any settlement on the piece rates question they are bound to follow the lead of the Controller. The interpretation Sir Evan Jones puts upon the national formula is that the Yorkshire miners are entitled to an advance of 12·2 per cent. on piece rates. This frame of mind on the part of the West Yorkshire owners is a sore point with Mr. Smith and his colleagues, as is illustrated by an incident which occurred in London on Friday. The meeting was arranged at the request of the South Yorkshire Joint Board, but as any settlement in South Yorkshire would inevitably react upon the western part of the county, the Coal Controller invited the West Yorkshire owners to send representatives. When the various parties assembled, Mr. Smith made an emphatic protest against the presence of the West Yorkshire owners. Possibly he feared the introduction of a discordant note, although his attitude was somewhat curious in face of his oft-repeated contention that county questions ought to be settled at meetings at which owners from all parts of the county were present, rather than sectionally. However, Mr. Smith persisted in his protest, and the West Yorkshire owners did not attend the conference. It is interesting to note that Mr. Frank Hodges, secretary of the Miners' Federation, attended, and it is understood that he explained very fully to Mr. Smith the federation's policy in agreeing upon a national basis. The Yorkshire leader, however, held his ground, and the outcome of the negotiations is that for the time being a settlement appears to be as distant as ever.

A number of meetings have been held since, and at the close of one which took place at Barnsley on Tuesday, the Council of the Yorkshire Miners' Association decided to advise the men to resume work, owing to the absence of support from the Miners' Federation and to the attitude of the Coal Controller.

Branch meetings were held subsequently.

Speaking last Saturday at the ordinary general meeting of the Consett Iron Company, Limited, held in Newcastle, the chairman, Mr. Mark Fenwick, stated that during the war 3,619 of the company's workmen had joined His Majesty's forces, and that 114,000*l.* had been paid to dependants. Dealing with the company's operations in the past year he said it had been difficult to get tonnage to bring iron ore from Bilbao, and, therefore, the company had purchased two steamers, and it might be desirable to purchase more boats in the future. In conjunction with Messrs. Guest, Keen and Nettlefolds, Limited, the company had purchased from the Public Trustee the shares in the Orconera Iron Ore Company, formerly belonging to Kruppa. The price paid was high, but it was hoped the investment would be remunerative. The effect would be to put the ore on the open market. At the present time, owing to the prevailing unrest and uncertainty as to the future, it had not been regarded prudent to embark on any schemes of large expenditure.

This was to be regretted, because, with the signing of peace, there was a great opportunity to increase the manufacture of iron and steel, the requirements being enormous, especially in devastated areas. The regular working of the steel works and rolling mills had been interfered with since April this year by the operation of the 8-hour day, and it had not yet been found possible to work the whole of the plant under that system. In the change of shifts they had not been able to find sufficient men. During the second half of the year a large number of men had returned to work in the mines, but, in spite of that, the output of coal for the year was actually less than in the previous year, the decrease of output per man being most alarming. The reduction of hours would, it was feared, still further decrease the production of coal. If the output did not improve the position in the country for want of fuel would be most lamentable. We stood in danger of losing our export trade, and other countries might come in. The restrictions on our export trade could not fail to have an important bearing on national finance.

The company was introducing more coal cutters in the hope of increasing the output.

Mr. Fenwick further stated that he was strongly opposed to the nationalisation of coal mines, and added that no State enterprise had been sufficiently successful to justify any Government in the taking over of the collieries.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Sufficient coal has reached here from outside areas to enable the local industries to maintain an appearance of partial activity. Nottinghamshire and Derbyshire collieries are contributing as much of their output as they can share, and supplies are coming from much further afield. One of the largest rolling mills in Sheffield, which has been closed for three weeks, reopened yesterday, having secured several hundred tons from Scotland. Production, however, is very seriously hampered. It is doubted by trade experts whether Sheffield's gross weekly output of steel equals the city's pre-war average. But for the wider adoption during the recent years of electricity for heating and driving purposes, trade would be much more seriously affected. As it is, by maintaining the electricity driven plant and suspending production in the largest coal-consuming departments, engineering firms are able to avoid absolute stagnation. Taking advantage of the slump in activity, several of the largest forges and foundries have set down their plant for overhauling and repairs. Prices of all classes of finished and semi-finished materials are steadily mounting. Consumers have received advices of a further advance of 20*s.* a ton on bar iron, making the South Yorkshire quotation 22*l.* 10*s.* delivered. A similar rise is notified in iron castings, and hoops have been brought to the record level of 24*l.* 5*s.*, by an addition of 30*s.* a ton. Manufacturers regard the pig-iron situation with some misgiving. For several months the output has been barely sufficient to meet immediate requirements. But now the local blast furnaces have been compulsorily idle for over three weeks and a similar period must elapse before production is resumed, scarcity approaches famine conditions. In these circumstances consumers are compelled to avail themselves of American offers. It is stated orders have been placed for a substantial tonnage of basic material at a delivered price 15*s.* to 1*l.* below local quotations. Steel billets have moved in proportion to other advances. Sheffield makers have determined on the following revision; Siemens acid, 19*l.* 12*s.* 6*d.*; Bessemer acid, 19*l.* 2*s.* 6*d.*; hard basic, 16*l.* 10*s.*; soft basic, 15*l.* 5*s.* New business for manufactured goods is restricted. Many inquiries are in circulation, but export buyers are not readily inclined to close agreements at the high prices prevailing. Unfinished contracts on home account are sufficient to keep most of the engineering works going for a few months. The tool branches have a glut of arrears to wipe off. Wire goods are in strong demand.

South Yorkshire Coal Trade.—As a result of private conferences held in Sheffield and Barnsley this week, there is definite prospect of an early resumption of work. As the Coal Controller cannot be persuaded to sanction the South Yorkshire owners' offer of 14·2, it is highly probable the Miners' Association will be compelled to adopt the national formula. Several weeks must elapse, however, before general working conditions are restored. Several of the pits have suffered material damage which cannot at once be repaired. Business on 'Change is virtually at a standstill. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

Softening Hard Water.—United Water Softeners, Limited, 20–22, Lincoln's Inn Fields, W.C. 2, call attention to their system of water softening, by which the hard water is allowed to pass through a filter composed of the granular porous silicate known as "permutit." No chemicals are required, and there is no precipitation of solid matter. When a specified quantity of water has passed through the "permutit" filter, it requires to be regenerated by a solution of ordinary salt, which is allowed to flow slowly through it for some time. It is then ready to soften another quantity of hard water. This to-and-fro process of alternate softening and regenerating goes on indefinitely.

Electrification of Brazilian Railways.—The Brazilian Government, says Monthly Bulletin No. 3 of the British Chamber of Commerce in Brazil, have asked the sanction of Congress to enter into contracts for the electrification of the main line of the Central Railway from the Central Station to Barra do Pirahy, including the ascent of the Serra, and also of the suburban lines serving Rio de Janeiro. It is considered urgently necessary in view of the growth of the city that a greater and more rapid railway service be provided at low rates. The preliminary surveys already authorised have now been completed, and the cost of electrifying the lines referred to is estimated at 5,593 contos (say, 340,000*l.*), and that of rolling-stock, power stations, &c., at 17,230 contos (say 1,050,000*l.*). On sanction by Congress being obtained, tenders will be invited, ample liberty being allowed for the proposal of any system of electrification as well as suitable bases for payment as credits are voted for the work.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Sales of Cleveland pig-iron are not numerous or heavy, the reason being that foundry kinds, which are the qualities in chief demand, are exceedingly scarce. Makers, in fact, have sold their output of foundry iron well up to the end of the year, and are disinclined to make further contracts, as with more local holidays coming on, production of foundry iron is not at all likely to increase. Present output is going straight into consumption. There is an active foreign demand for foundry iron. The lower qualities of Cleveland pig-iron are very plentiful and are something of a drug on the market. For home consumption, No. 3 g.m.b., and No. 4 foundry, are 160*s.*, No. 1 is 164*s.* and No. 4 forge 157*s.*; and export prices are 5*s.* above these rates.

Hematite Iron.—East Coast hematite keeps strong, though there is rather more offering for prompt business in consequence of the continued suspension of deliveries to Sheffield due to consumers there being unable to obtain coal supplies. Most producers, however, have good order books. Continental inquiry, however, shows some falling-off. Mixed Nos. are 200*s.*, No. 1 is 202*s.* 6*d.* for home use, and the export quotations are 205*s.* and 207*s.* 6*d.* respectively.

Foreign Ore.—There is little or nothing passing in foreign ore. Consumers are quite comfortably placed, and are not in the market to make further purchases just now. Rubio, of 50 per cent. quality, is quoted round about 53*s.* 6*d.* c.i.f. Tees, and the freight Bilbao-Middlesbrough is in the neighbourhood of 25*s.*

Coke.—Foreign trade in coke is small, but home transactions keep rather numerous, and heavy local needs are receiving adequate attention. Average blast-furnace kind is 48*s.* at the ovens, and low phosphorus quality 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—The position as regards finished iron and steel shows little or no change. Works are very fully employed on contracts already booked to meet urgent home needs, but few new orders appear to be coming along and foreign trade is very quiet, the high prices, necessitated by heavy cost of output, making successful competition in markets abroad exceedingly difficult. The return to work of the local engineers after their abortive strike should result in some increase of production, which is very much needed. Prices, all round, are unaltered. To home customers common iron bars are 22*l.*; marked bars, 24*l.* 10*s.*; strip iron, 22*l.* 5*s.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; steel hoops, 23*l.*; galvanised steel sheets, 24-gauge, 28*l.* 10*s.*; and heavy sections of steel rails, 16*l.* 10*s.* Export prices are still matter of individual negotiation.

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England have certified the average net selling price of iron bars and angles for the two months ending June 30 last, at 20*l.* 19*s.* 1·73*d.* per ton, as compared with 18*l.* 5*s.* 7·68*d.* for the previous two months, and the secretaries to the Board report that on these figures the sliding scale gives an advance of 27½ per cent., but subsidies on pig-iron having ceased the 10 per cent. which was added as the equivalent of the subsidies is now discontinued, leaving a net advance of 17½ per cent. on puddling and other forge and mill wages.

Engineers' Strike.—The strike of engineers on Teesside which has lasted a couple of months, has come to an end as the result of a ballot taken by the men. The main point of dispute centred in the question of the 44-hours' week, and the ballot showed a majority in favour of the acceptance of the offer made by the employers for a joint conference. The men were instructed to return to work last Monday morning.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The conditions prevailing in the Scotch steel trade are somewhat uncertain at the present time, and while makers are unwilling to book anything but prompt business, buyers themselves are not anxious to fix up beyond their immediate requirements. Several schemes which would have been gone on with before now are being held back owing to the present high prices for Scotch steel, and only work which is actually of an urgent nature is being proceeded with. Should the foreigner manage to offer material in the home market at rates considerably under local prices, and guarantee good delivery, of course it is not unlikely but that he will secure a number of orders, and later on our home workers will then feel the pinch through short time or unemployment. In the meantime it looks very much like coming to that through the loss of so much of our overseas trade. Our export of steel is on a very small scale at the present time and the latest advance in prices through the rise in coal has had the effect of checking foreign business. The home trade is good just now, and as the Clyde shipbuilders are busy the demand for plates is rather urgent. This state will last for a bit, as order books are very well filled, but what may take place when present orders are worked off no one cares to forecast. The "ca' canny" policy which has been so much in evidence is a decidedly bad one at a time when the world requires so much material to replace the losses of the war, especially as we could have secured a very large proportion of the orders under fairly normal conditions. We are not without hope, however, but that things will improve and that much Scotch steel will yet be used in the rebuilding of the Continent. Makers of black sheets have advanced their prices by 10*s.* per ton, and the basis price is now 22*l.* 10*s.* per ton for ¼ in. The export rates are also up. There is a very small demand for angles and sections but there are a goodly number of orders on hand at the present time.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland are very well employed on immediate business, and are barely able to cope with the demand. Orders already booked amounted to a large tonnage and consumers are now pressing for delivery, but owing to the present high level of prices contracts are not being fixed up quite so freely. The current price for "crown" bars is 21*l.* 12*s.* 6*d.* per ton, net, f.o.r. Glasgow area, while for export lots the price is called 22*l.* per ton, net, f.o.b. Glasgow. Export departments are not very busy at the moment, and the bulk of the business going through is on home account.

Scotch Pig-Iron Trade.—The feature of the Scotch pig-iron trade is the present scarcity, coupled of course with the very high price. The latter condition is having the effect of curtailing new business, and fresh bookings are being kept down to the smallest scale consistent with actual requirements. The general position of the trade shows little or no change over the week and a steady demand prevails for orders on hand. For hematite iron there is still great pressure for deliveries on behalf of the local steelmakers. Prices are very firm all round and show no alteration.

Scotch Coal Trade.—The Scotch coal trade is moving along rather quietly and the various pits are now mostly all working full, but there are one or two exceptions. The output does not yet come up to expectations, and the coalmasters are thereby being hampered in their dealings. The large coal-consuming works in the West of Scotland are again taking in heavy deliveries of fuel, and so also are the railway companies and the gas works, but owing to the fine weather there is little demand for household qualities. With coal selling at such high prices every endeavour is being made to curtail waste, and fuel is having attention concentrated on it and tests are again being carried out. Export business is not very brisk, and all round the prices are steady and firm.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The principal feature of the coal markets during the past week has been the continued extreme scarcity of coals and the high prices paid for the small isolated parcels that collieries have been able to dispose of. Outputs have been further reduced by a large percentage of absenteeism on the part of the miners, and it is estimated that at present only about two-thirds of the colliers are back at work. The remarkably fine weather has no doubt induced a large number of men to prolong their holidays. The continuance of the Yorkshire miners' stoppage has also had an appreciable effect, for the authorities have continued to requisition practically the whole of the production, which is about 30 per cent. below normal, with the result that the quantity available for export has been reduced to almost negligible limits. Though there is now a prospect of the Yorkshire miners resuming work in the immediate future, it will be some time before outputs can be brought up to the level prior to the strike, though the pressure for supplies inland from this district is now likely to relax gradually, and it is possible that there will be an increase in the volume of shipments. There is an abundance of shipping at the various ports, many vessels have already been waiting over a fortnight for cargoes, and instances are known of boats that have been in the Barry roads waiting to come into dock for a month and more. Already a large number of steamers have sailed without cargoes to other markets. Actually, business in the circumstances is very quiet and difficult to bring to a conclusion, and is chiefly confined to the purchase of parcels here and there for the bunkering of steamers. For these odd parcels salesmen are securing high prices, Admiralty large coals being worth anything from 75*s.* to 80*s.*, with ordinary large from 70*s.* Small steams, too, are very scarce, and for the best descriptions 65*s.* is readily paid, with some sellers demanding 70*s.* Coke is also insufficient to meet the demand, and 100*s.* per ton has been paid for export to France. The drought has affected the make of patent fuel, as several manufacturers have been unable to continue work owing to the scarcity of water. Supplies are extremely scarce and prices are nominal from 75*s.* to 80*s.*

Newport.—Monmouthshire coals are totally insufficient to meet the demand, and for the isolated available parcels sellers can secure from 70*s.* for Black Vein, Western Valley and Eastern Valley large, while the cheaper grades range from 65*s.* Smalls, too, are in active demand and scarce, and for the best descriptions 55*s.* can be secured with the lower qualities from 45*s.*

Sunken Vessel Raised at Barry.—The Cornish Salvage Company (1918), Limited, has just brought to a successful conclusion a remarkable piece of salvage work at the Barry Docks. In October of last year the mystery ship M. J. Hedley, whilst loading a cargo of coals, capsized and sunk. The Cornish Company were entrusted with the task of raising the vessel, and after ten months' work have succeeded in floating the M. J. Hedley and handing her over to the Admiralty, by whom she was requisitioned. First of all the vessel, which lay on her starboard side, submerged, was uprighted by the aid of two railway locomotives and the salvage company's steamers Zephyr and Margaret, together with a couple of pairs of sheer legs, able to exert a pull of over 150 tons each, which were erected in the dock. As the vessel was still lying submerged from 20 ft. to 30 ft. under the water and lifting barges were unobtainable, it was decided to build a cofferdam round the vessel. This structure was about 120 ft. long by 24 ft. wide and 30 ft. deep, and was built by divers entirely under water. The magnitude of the undertaking can be gathered from the fact that one side of the cofferdam had to be strong enough to stand a pressure of 1,000 tons, and the whole box had to be made watertight and fitted on to the ship. The total length of the watertight joints made by the divers was nearly 2 miles. Yet so well had the divers done their work that when pumping operations were commenced on August 5, within 4 hours the bow was showing out of water and on the following morning the vessel was afloat fore and aft. The taking down of the cofferdam was an operation of anxiety, for every precaution had to be taken to prevent the vessel from capsizing and sinking again.

CONTRACTS.—Messrs. Clayton and Shuttleworth, Limited, Lincoln, state that during the last two or three weeks they have booked the following contracts: India Office, for use on North-West Frontier, Six 5-ton Clayton steam wagons, with steel tyres, fixed bodies and water tanks; Nottingham City Council, Engineer's Department, two 5-ton Clayton steam wagons, with steel bodies and rubber tyres; Glamorgan County Council, one 5-ton Clayton steam wagon with rubber tyres; Glasgow Corporation, one 4-h.p. compound tractor, with rubber tyres.

WILLING'S PRESS GUIDE.—A copy of the forty-sixth annual issue of this useful publication has recently come to hand. This edition retains the well-known features of previous volumes, and maintains its reputation for being the most convenient and reliable source of information as to the Press of the world. A considerable part of the volume is occupied with an alphabetical list of the newspapers and periodicals of the United Kingdom, the list giving the year of establishment, time of publication, price, and the name and address of the publisher in each case. There are also lists classified geographically and in accordance with the subjects dealt with, lists of metropolitan and provincial newspapers, notes as to changes of titles and amalgamations, and lists of the principal foreign and Colonial newspapers. The volume which includes over 500 pages is bound in paper-covered boards with cloth back, and is sold by Messrs. James Willing, Limited, 125, Strand, London, W.C. 2, at the price of 2*s.*

PERSONAL.—Messrs. Frank Wigglesworth and Co., Limited, of Clutch Works, Shipley, announce that they have purchased the millwrighting business of Messrs. George Richards and Co., Limited, of Broadheath, Manchester, together with their pulley plant and patterns, and are now the sole manufacturers of the type of pulley which that firm have manufactured for the past thirty years. Messrs. Frank Wigglesworth and Co. have built up-to-date shops for the manufacture of the Richards' pulleys.—In order more adequately to deal with impending developments of high and low-tension overhead transmission and distribution work, a consolidation of interests has been arranged between the Twiss Engineering and Electric Transmission, Limited, and Messrs. J. B. Saunders and Co., Limited, and Mr. Sydney G. Leech joins the Board of the Twiss Company and Mr. G. V. Twiss becomes a director of Messrs. Saunders.—The Westminster Tool and Electric Company inform us that owing to the difficulty of meeting the demand for their Westool portable electric drills and other tools with their present facilities, they are erecting new works at Putney at which they are concentrating their head office. In future, therefore, their address for all communications intended for their head office or works, will be: Westool Works, 116, Putney Bridge-road, Putney, London, S.W. 15. The firm's new telephone number will be "Putney 1179" and their telegraphic address "Westolelco-Put, London."

AMMONIA FROM COKE AND COAL.—A research on the influence of steam on the gasification of the nitrogen in coke and coal and on the ammonia yield of this gasification was conducted a few years ago by Hermann Salmang at the Technical High School of Aachen. An abstract of his dissertation was recently published in the *Zeitschrift für Angewandte Chemie*, on page 148 of this year's volume. The coke first experimented with contained 1·01 per cent. by weight of nitrogen and 0·89 per cent. of hydrogen, that is, many times more hydrogen than the formation of ammonia required. Yet when he gasified coke at about 1,100 deg. C. in an atmosphere of dry carbon dioxide, practically no ammonia was formed. In moist CO_2 a little ammonia was obtained. On the addition of steam in considerable quantities, 38 grammes of steam, *e.g.*, per gramme of coke gasified, nearly one-third of the nitrogen was converted into ammonia, and this yield could further be improved by admitting air and by adding carbonate of calcium or iron oxide. With lime, steam and air the conversion was almost perfect, and could be effected at the lower temperature of 900 deg. C.; the addition of lime was particularly useful in the case of anthracite, where it raised the ammonia yield by 12 per cent. to 94 per cent., but had little effect with ordinary coal. Peat coke gave less ammonia than other coke. From the abstract it is not clear on what scale the experiments were conducted; grammes and kilogrammes are mentioned, but larger masses may have been dealt with. The presence of steam, at any rate, seems to be essential for the ammonia formation, and one other point is brought out by the research—the ratio of nitrogen to carbon in the coke was the same after the gasification as before; that shows, that the nitrogen is uniformly distributed through the coal and bound by it.

PATTERN-MAKING MACHINE.

CONSTRUCTED BY MESSRS. WADKIN AND CO., LEICESTER.

(*For Description, see Page* 221.)

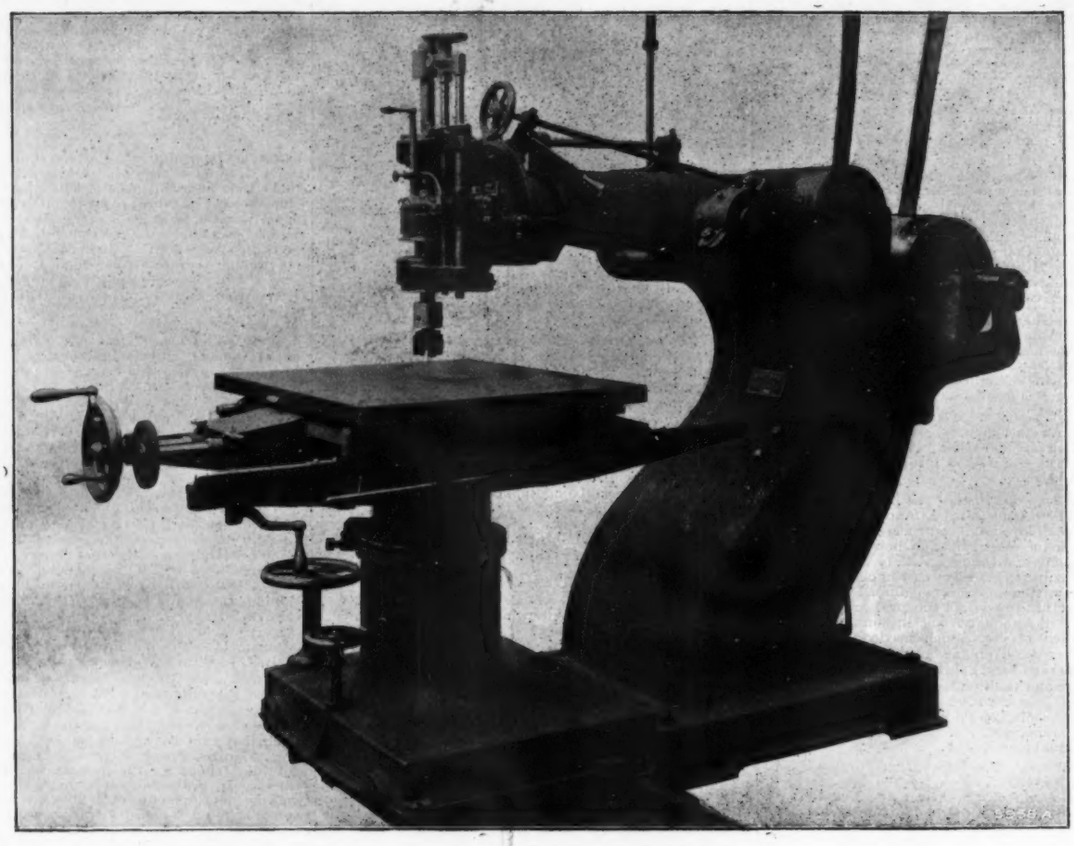


Fig. 1. Machine with Head in Vertical Position.

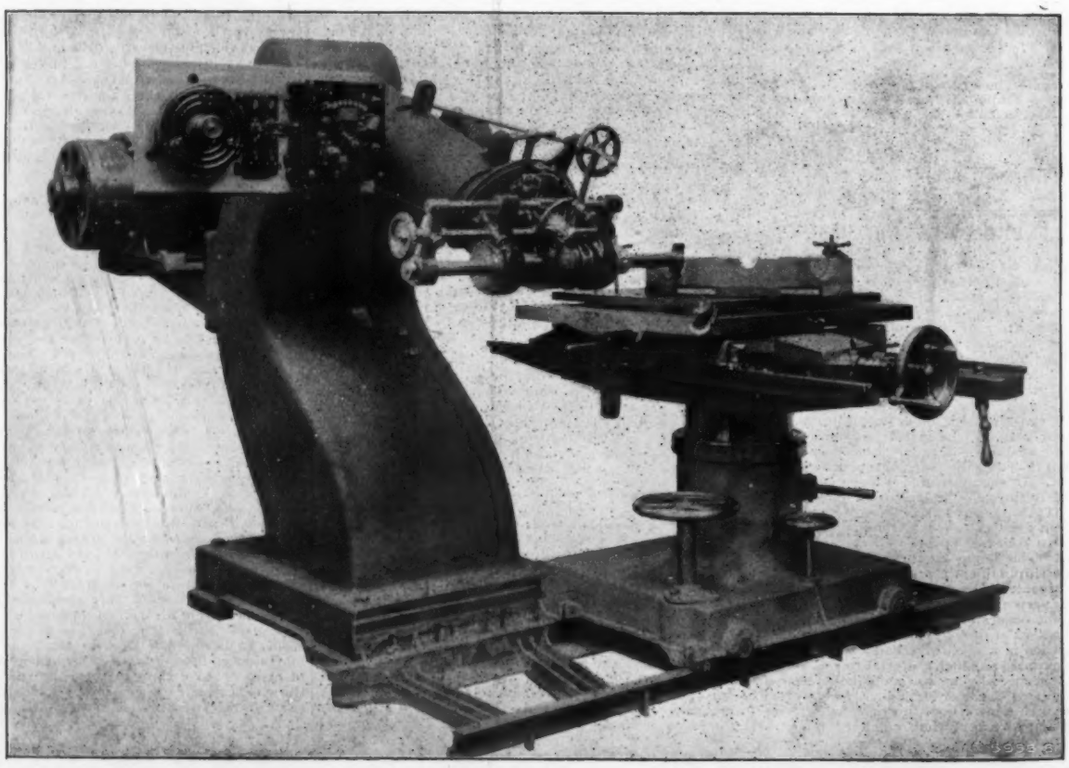


Fig. 2. Machine with Head in Horizontal Position.

H.M. AEROPLANE-CARRYING CRUISER FURIO

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, NEWCASTLE-ON-TYNE; E[illegible]D BY T

(*For Description* [illegible]*ge* 203.)

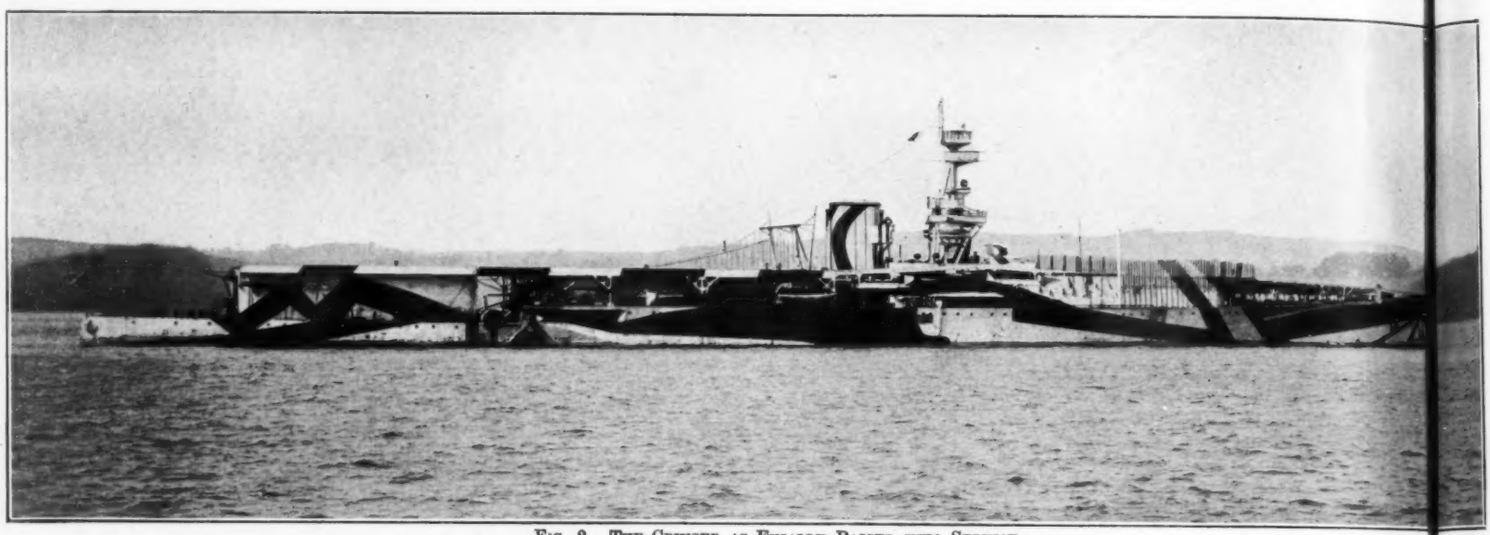


Fig. 2. The Cruiser as Finally Passed into Service.

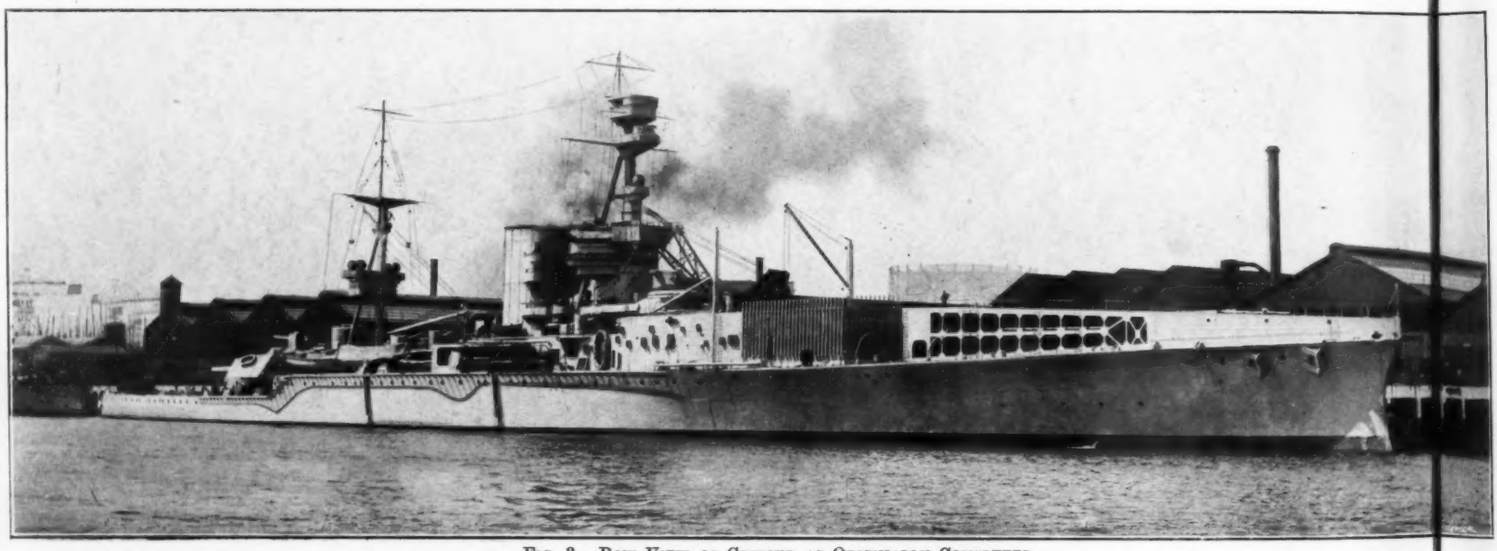


Fig. 3. Bow View of Cruiser as Originally Completed.

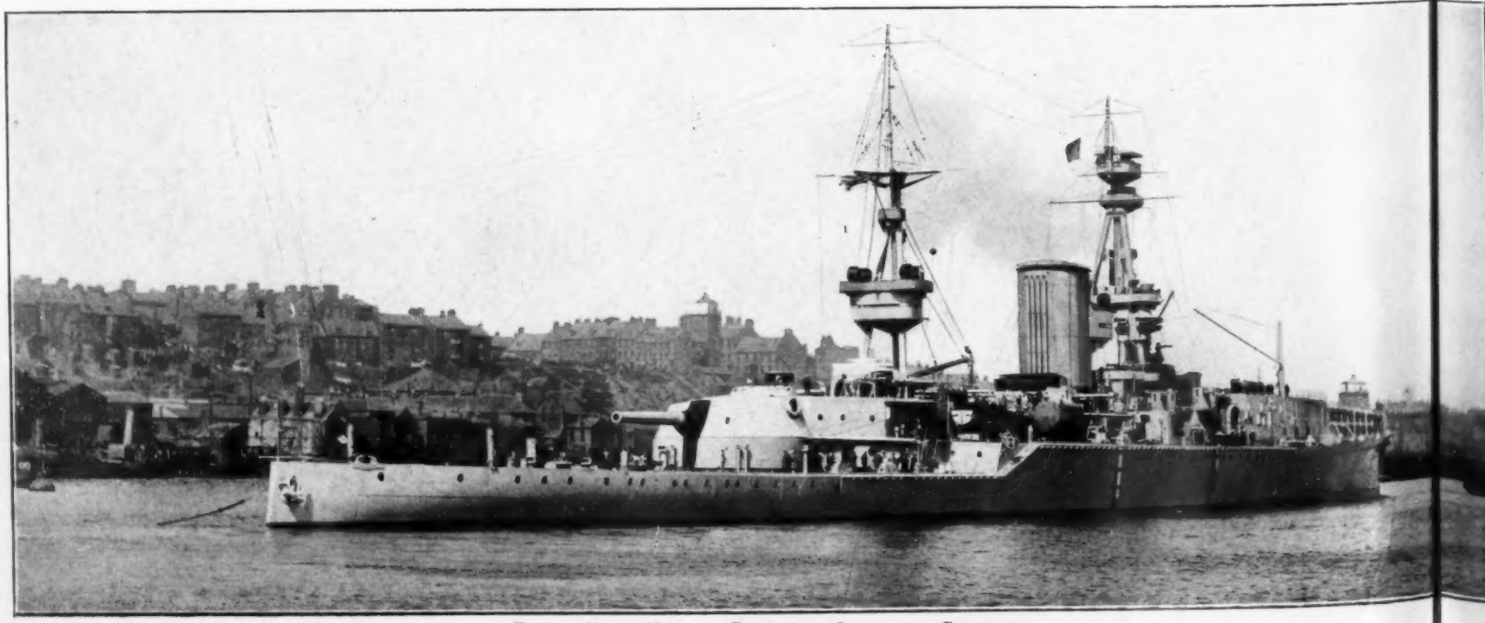


Fig. 4. Stern View of Cruiser as Originally Completed.

"FURIOUS," WITH GEARED TURBINES.

BUILT BY THE WALLSEND SLIPWAY AND ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(For Description, see page 203.)

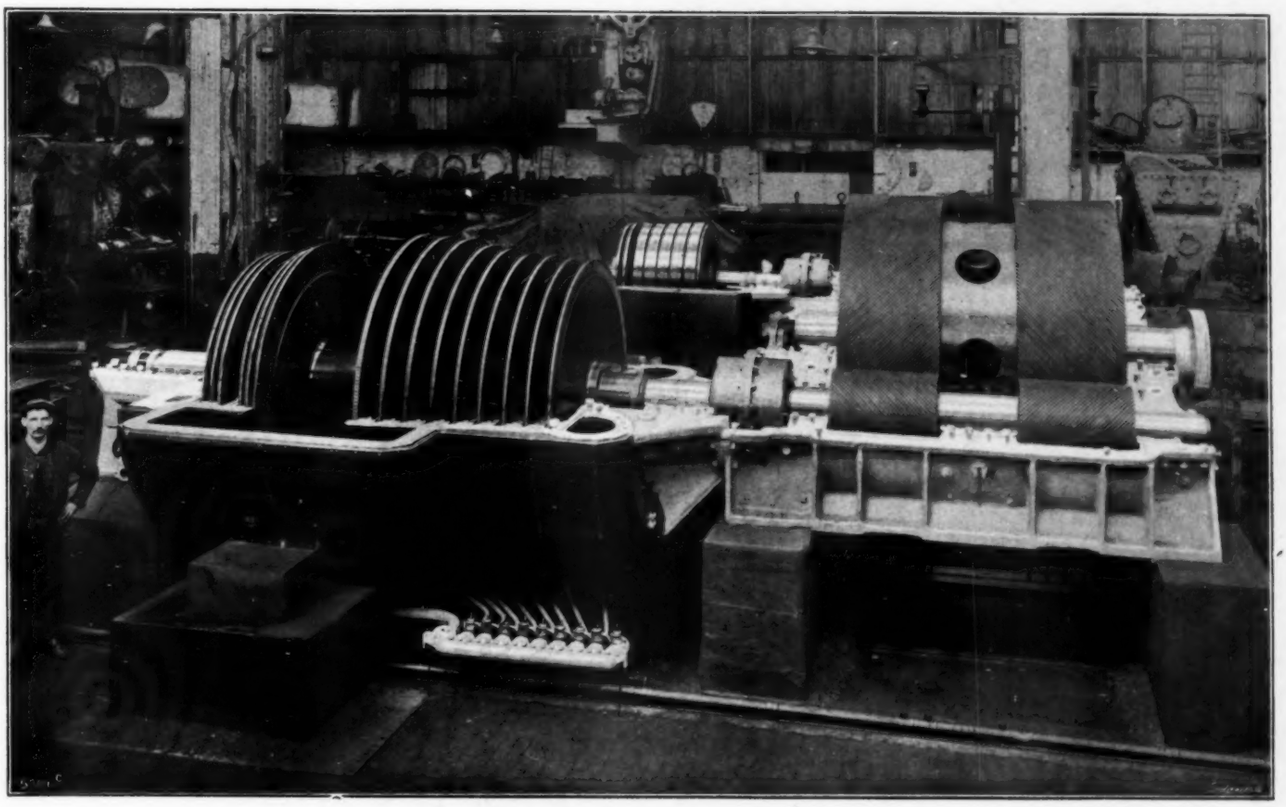


FIG. 5. LOW-PRESSURE AHEAD AND ASTERN TURBINES.

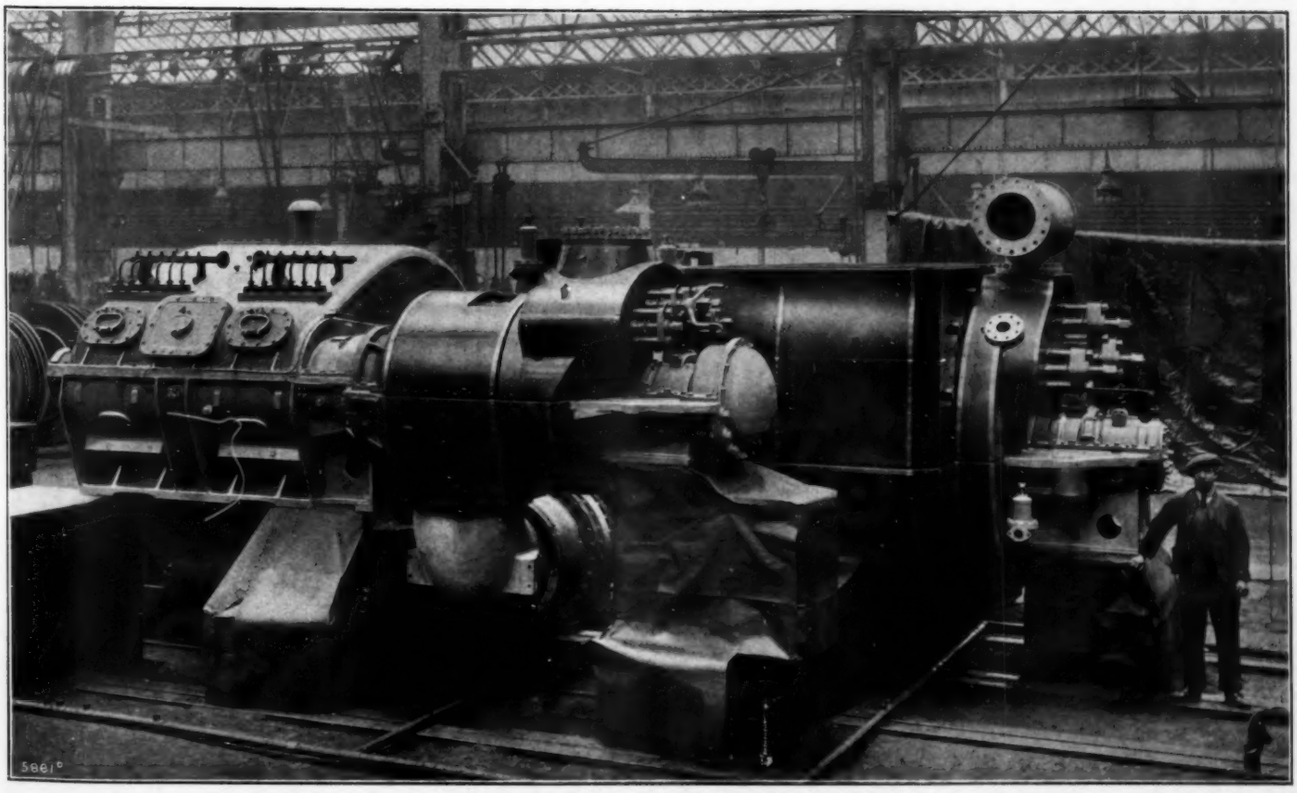


FIG. 6. SET OF GEARED TURBINES COMPLETED.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 15, 1919.

THE IMPROVEMENT OF THE ELECTRICITY BILL.

THE Government's Electricity Supply Bill is being much improved during its passage through the Grand Committee appointed by the House of Commons to consider its details. It will be remembered that the general scheme, in brief, is for the appointment of five Electricity Commissioners who will practically control the whole business of electricity supply throughout the British Isles and will be subject only to the Board of Trade, or the Minister of Ways and Communications—the latter as the Bill now stands. These Commissioners, according to the original intention, were to divide the country up into electrical districts and to appoint District Electricity Boards to administer them. These Boards were to purchase, or become possessed of, all generating stations and main transmission lines in their district excepting only private stations.

One of the most important amendments which has been introduced, in Committee, has reference to the creation of these District Boards. Originally a Board was to be appointed for every part of the country so that all existing electricity supply authorities *ipso facto* went out of existence. Such authorities might be represented on the Board, but they would not be the board of the people who had built up and administered a successful electric supply business; nor would the originators of an efficient scheme necessarily continue to carry it on. Further, the districts were to be mapped out and the Boards appointed by the mere fiat of the Electricity Commissioners. Local knowledge and experience could, if the Commissioners so ruled, be entirely ignored. According to the amendments made, the Commissioners have to hold a local inquiry before an area can be demarked, and have to give existing authorities and local interests an opportunity of putting forward a scheme of their own for a joint electricity authority for the district, or other such proposal as may seem desirable. Only in the event of no acceptable local proposals being forthcoming are the Commissioners to proceed to the creation of a District Board of their own and a local inquiry has to be held before that Board can be constituted.

This matter appears to us to be of the first importance. A study of the Bill as originally drafted suggests that its authors, knowing little of electricity supply, had yet been enormously impressed with the case which can be made out against the present general condition of the business in this country. They would appear to have realised, apparently for the first time in their lives, the technical and economic disadvantages of numberless self-contained small supply systems with a maze of different voltages and periodicities. This engineering commonplace having been digested they went in for something really big and thorough, and envisaged some half-dozen "super-stations" supplying electricity to every city and village, driving every train and mill, and illuminating alike the palace and cowhouse. These things, we admit, could be done technically, but they are meet rather for Mr. Well's "New Utopia" than for the hard-up British Isles. Judging from the advances which the employment of electricity has made in the last thirty years, one may reasonably conclude that much yet lies in store for it, but that is no reason for cutting the painter and abandoning all we have so far achieved.

Electricity supply is not only a matter of generating stations and transmission lines. Like all business an important part of it is formed by specialised knowledge and experience, local interest, personality and accumulated organisation. To abandon the whole of this valuable material and start anew to build up a new organisation and *personnel* would be folly. Although taken as a whole our present method of conducting the business of electricity supply is impossible to defend on any score, we none the less have large areas in which the methods and results are on an equality with the best similar work which is done elsewhere in the world. Some such scheme as that put forward by the Government for unifying the business and eliminating many of the small independent authorities is certainly urgently required, but the road to a better all-round state of affairs most certainly does not lie over the abandonment of all our existing successful organisations. Let us keep what good we have and at least begin with an improvement of the backward.

There is no difficulty in finding examples of electricity supply organisations which, for the present at least, had much better be left alone. No good purpose, for instance, would be achieved by interfering with the business which is so successfully carried on by the Manchester Corporation and turning it over to a Board appointed by an outside body. We have not looked into the details of the matter, but it is quite possible that a technical and economic case might be made out for amalgamating the electrical interests of Manchester and Salford, and possibly bringing in the Lancashire Power Company. In the amended Bill there is nothing to prevent this being done, and, as Salford already interworks with the Lancashire Power Company, such a development is not unlikely, but any amalgamation scheme will now be evolved locally and the contracting bodies will retain their individuality. This is much better than turning everything over to a new authority, a District Board of cast-iron type, which for all business purposes would have to start the whole thing anew. Very particularly in the matter of economy is the amended arrangement to be praised. Existing undertakers know their plant and know their market, and are not likely to be led into expenditure on grandiose schemes for which there is no local justification. We do not wish to suggest that the proposed District Boards are likely to act foolishly, but we think the local experience of existing authorities will give them an advantage of judgment which the District Boards could hardly attain.

No great number of years ago local jealousies were so apparent in connection with electricity supply that it is doubtful if any adequate schemes of interworking were likely to be proposed by existing authorities. Of late, however, a wider knowledge and a better spirit are abroad. An example of the evidence illustrating this is furnished by the recent report of the Linking-up Committee appointed by the various suppliers of Yorkshire. The report proposes a central authority for Yorkshire to deal with questions of interworking. We do not know that the report goes to the lengths which are contemplated in the Government Bill, and certainly the proposed central authority is of unwieldy dimensions, but the fact of the appointment of the Linking-up Committee shows that local undertakers are alive to the necessity of improving our existing methods. As the area with which the report is concerned covers a large number of small suppliers, it is probable that something more than linking-up is necessary and that the Electricity Commissioners may find it necessary to appoint a District Board. The amended Bill, of course, still allows this, the amendment with which we are dealing being only concerned with the preservation of large and efficient existing organisations, and not with the continuance in being of the small and necessarily inefficient areas, the existence of which is one of the main causes of the Bill being brought forward.

Another amendment which has been introduced into the Bill has reference to generating stations belonging to railway companies and dock systems. Originally it was proposed that these should be taken over in the same way as all stations connected with public supply. They are now definitely excluded from the operation of the Bill. This amendment is of less value than the one we have

dealt with above and technically it may be criticised. The idea behind it probably is some curbing of the extreme powers which it was originally proposed should be given to the Ministry of Ways and Communications. In many cases a technical case could no doubt be made out for absorbing a dock generating station into a general system, but at the worst the amendment will do no harm. The Electricity Commissioners will find plenty of work to their hands at first, and if later they bring about the advances we all desire there will be no difficulty in arranging interworking with dock and railway authorities if it can be shown to those bodies that such interworking will give them a cheaper supply.

A further point which has been modified in the Bill concerns the price which is to be paid to companies whose property is acquired. In the case of a generating station or transmission line taken over from a company, or a person, it was originally proposed that the price paid should be the cost of construction and acquisition of the site, less depreciation. As amended the Bill specifies definitely that lands, buildings, works, materials and plant suitable to and in actual use by the company or person for the purpose of their undertaking shall be so paid for, and in addition the amount of the expenses incurred as and incidental to the construction of the station or transmission line, shall be paid, as also a sum as compensation for any damage shown to be sustained by any company, body or person due to the severance of the generating station or transmission line. This is very clearly an improvement. The clause has been made much more definite, and leaves less loophole for the harsh interpretation which was possible in the original draft.

Two further small matters we may mention are first the insertion of a section specifying that in the event of any change in type of current, frequency or pressure in a station acquired by a District Board, any expenses arising as a consequence to the original owners, who may still be supplied from the station, shall be liquidated by the Board. The other point is the insertion of a new clause in the Bill specifying that three of the five Electricity Commissioners shall be selected for practical, commercial, or scientific knowledge or wide business experience, including that of electrical supply. This new clause is excellent. We are no believers in the possibility of State management on commercial lines, but any attempt in that direction has all our support. The clause should ensure that at least three of the Commissioners will know their job and removes more than half of the Commission beyond the reach of Blue-book compilers and general political hangers-on.

GAS TRACTION.

Town gas as a propellant for internal combustion engine vehicles performed a useful function in the war, but it was mainly looked on as a makeshift, and with the coming of peace appears to have pretty well dropped out of use. Gas traction had been used earlier to some extent in connection with tramway propulsion, but the advent of the flexible container and the application of gas to petrol vehicles dates back only to the summer of 1916, when Messrs. Andrew Barton and Brothers began to run a single-deck Thornycroft motor-bus between Beeston and Nottingham. This pioneer work was quickly followed up, and, as is common knowledge flexible containers were fitted in large quantities by vehicle owners who found themselves hampered by the shortage of petrol. This method of avoiding the restrictions of the Petrol Control was, however, in turn hampered by the growing coal shortage, and on January 3, 1918, gas permits were inaugurated. These permits did not limit the amount of gas which could be used by a converted vehicle, but on March 26 of the same year gas rationing was instituted. The final position was that vehicles converted to gas on account of petrol shortage found themselves committed to a fuel which in its turn had become shorter still, and many gas equipments were as a consequence abandoned. The coal and consequently gas shortage, we need scarcely say, has persisted until to-day.

It is reasonable to suggest that gas traction would have shown considerable further advance had coal supplies remained normal, but when the effect of the conversion of a vehicle was merely to turn it over from a fuel of which there was a shortage, to another of which, if anything, there was an even greater shortage, it is not surprising that the development received a check. According to the Inter-Departmental Committee on Gas Traction, there were 5,000 gas-equipped motor vehicles in January, 1918, and by the following January the number had fallen to 3,600. The figure now is probably considerably smaller. As long as petrol is to be obtained it cannot be expected that gas traction will make any considerable headway unless it can be shown to have technical or economic advantages, but, in view of the national importance of using a home-produced fuel and restricting imports, it is desirable that the employment of gas should be fostered as far as possible, assuming, of course, that a reasonable case can be made out for it.

The general impression among motor vehicle users throughout the country probably is that gas will work all right, but that it is a nuisance, and that they will prefer petrol as long as they can get it at a price in any way comparable to the corresponding price of gas. This idea is, we think, based partly on inherent fact and partly on experience of conditions common to most new developments. The flexible container as employed in many cases was certainly a very crude job, and not infrequently a fitted vehicle gave the impression of some metamorphic creature evolving from a motor car to an airship. Further, in many cases trouble was experienced with gas loss, due to the employment of unsatisfactory fabric. This restricted the mileage run per charge and accentuated what is undoubtedly a weakness of the application in almost any form. Against these disabilities must be set the remarkable freedom from accident which this new and hurried development is able to show. Danger from fire is the consideration which the gas-bag vehicle brought to most people's minds, but the committee to which we have already referred are able to quote only three cases of fire during the whole period of this revival of gas traction. One was due to the bursting of a flexible container while the car was in motion shortly after re-charge. Another was due to the ripping of the container on a street lamp, and the third arose from the filling pipe slipping out of the feed pipe during charging, so that the gas became ignited from one of the side lamps of the car. We have personal experience of a similar accident to this latter, but cannot say if this raises the total number of cases to four, as the incident may be the same as that quoted by the committee. In the case of which we have knowledge the car was damaged by fire, but not seriously, and was on the road again in a few days.

We have said that it is desirable to foster gas traction, since it represents employment of a home-produced fuel. None the less no amount of fostering is likely to lead to its considerable use unless a reasonable technical case can be made out for it. In this direction the report* of the committee we have already mentioned is promising. On the question of economy it is estimated that 250 cub. ft. of town gas are on the average equivalent to one gallon of petrol. The relative economy this ratio may stand for will vary enormously owing to the great variations in the price of gas, but as an example the Scottish Motor Traction Company during 1918 ran over 1,000,000 miles partly on gas and partly on petrol. The total petrol cost, at 2*s.* 4½*d.* per gallon, was 10,674*l.*, and the total gas cost, including cost of bags and attendants' wages, was 10,843*l.* Debenzolised Edinburgh gas was mostly used, and the price paid per 1,000 cub. ft. was 3*s.* 8½*d.* The total fuel bill was 21,517*l.*, and had petrol alone been used, and reckoning five miles to the gallon, which agrees with the company's usual experience, the total fuel bill would have been 28,002*l.* This shows a saving of 6,484*l.* as a result of using gas. There was, however, a loss of earning power with gas owing to time lost in filling, which the company estimate cost 3,285*l.*, leaving a credit balance on the side of gas of 3,199*l.* a year. These figures relate to a fleet of 40 motor-buses.

Other evidence was furnished by the Great Grimsby Street Tramways Company, who estimated that for every 1,000 miles run on gas they made a saving of 15*l.* as compared with petrol, and after meeting all charges. A large part of the gas supply they used had not been debenzolised, and they found 240 cub. ft. to be on an average equivalent to one gallon of petrol. Some work with gas traction was also carried out by the London General Omnibus Company. On the Cricklewood-Victoria route experimental running was undertaken with compressed gas in cylinders. A compression pressure of 1,000 lbs. per square inch was employed. The compression plant was of small capacity, being suitable for 10 vehicles, and was used intermittently, and it was found that the cost of compressing 1,000 cub. ft. of gas was 2*s.* 3*d.* Taking gas at 4*s.* 4*d.*, this made a total fuel cost of 6*s.* 7*d.* per 1,000 cub. ft., which, against petrol at 2*s.* 4*d.*, shows a fuel saving of 29·5 per cent. in favour of gas. It is pointed out that these figures quote petrol at the price ruling for large contracts and gas at ordinary consumers rates. Were the figures on a common basis the ratio would show still more favourably for gas and obviously compression charges would fall with a large and continuously-running plant.

This possibility of using steel cylinders for the gas instead of flexible containers raises an entirely new aspect of this question. Anything else apart, it is obvious that the amount of room it takes up has always been an objection to the gas bag. For omnibus traffic this condition has restricted employment to single-deck vehicles, the upper deck being required for fuel storage. This involves a serious reduction in earning power. One has only to contemplate all the London omnibuses converted to single-deck vehicles to realise what it means, and there is no doubt but that if compressed gas is economical it should enormously extend the field for gas traction. The above figures given by the General Omnibus Company are very promising as far as they go; but fuller information is required on certain points connected with the experimental installation experimented with.

The committee has given much attention to this question of the use of compressed gas and reports entirely in favour of it. They make some detailed recommendations in connection with the size and thickness of the cylinders, and suggest working pressures up to 2,250 lb. per square inch. The cylinders when in position on the vehicle should be disposed within and totally enclosed by the body-work of the structure. It is regarded as preferable that they should be recharged in position. The recommendation of the Committee with regard to the use for traction purposes of gas stored at high pressures in steel cylinders include many points which are undoubtedly open to adverse criticism. The matter is too important to be dealt with in a general article like the present, which is only intended to indicate the main features of the report. We shall, however, return to the subject in an early issue and direct attention to certain features of the system advocated which do not appear to have received the full attention of the Committee.

Some work has been done with wire-wound cylinders with removable metal end-plates held in place by screwed longitudinal tension rods of steel. The committee, however, do not recommend them, and find that there is leakage at the ends when the internal pressure falls below about 35 atmospheres. The cylinders are also heavier for a given volume of gas than high-carbon or alloy steel cylinders made according to the committee's specification. It is possible that a built-up cylinder of this class may be cheaper and more easily obtained when a small quantity only is required, but if gas traction comes into being on any considerable scale the drawn steel cylinder would probably prove the more convenient and cheap. As a further alternative to the flexible bag, the committee are, however, inclined to favour a semi-rigid container consisting of an inner member or tube in the form of a rubber container and an outer casing of woven steel wire. This class of container is approximately one-third the weight of a steel container for a given volume

* *Report of the Inter-Departmental Committee on the Employment of Gas as a Source of Power in Motor Vehicles.* [Cmd. 263.]

of gas, and as it stretches on being charged give ample warning if overcharging be attempted. As this type of container can be dropped on to the ground with impunity, and as, if overcharged, the inner rubber member bursts without the wire casing being fractured, the construction should prove very safe in ordinary practice. The weight saving as compared with a steel cylinder may be of great importance. A working pressure of 45 atmospheres is recommended.

The report with which we are concerned also deals to some extent with portable suction gas-producers for use on motor vehicles. This development is clearly a somewhat different one from that of the employment of town gas, but it has in common the facts that it employs a home-produced fuel and is more or less directly applicable to existing petrol-engines, lorries, &c. It is stated that portable suction producers are available which, after the necessary attention at lighting-up, can be made to work automatically, and that their fuel cost with coke at 45*s.* a ton, or anthracite at 55*s.* a ton, is equivalent to petrol at 5·4*d.* a gallon. The weight of the generator and accesories for a 30 brake horse-power engine is about 220 lb. This certainly sounds a very attractive proposition. Some work was done with portable producers of this class before the war, but we do not know that they came into use to any considerable extent. The committee examined three appliances of this class, and they all showed close agreement as far as regards fuel consumption. The system due to Lieut-Colonel D. J. Smith was subjected to the fullest tests, and a lorry fitted with a Smith producer was run in all 277 miles on the road. The installation was to some extent a makeshift one, owing to shortage of materials, and was too large for the lorry to which it was fitted, but the general results were good. This development of internal combustion traction would appear to be well worth attention.

THE BRITISH ASSOCIATION IN 1918.

The Report of the British Association for the year 1918 was issued a few days ago. It is not a long report, and as we have dealt with the reasons which necessitated the cancelling of the meetings of both 1917 and 1918, and with some of the general features of the work in progress in our issues of July 12 and 19, 1918, we shall not have much to say on this occasion. The Bournemouth meeting, originally planned for 1917, is, moreover, to open within a few weeks, on September 9.

The general public is apt to overlook the fact that the most fruitful activity of the British Association and, to a certain extent, its *raison d'être*, are to be found in its committee work which continues throughout the year, and has continued during the war, though the annual meetings have been suspended. If the committee work had not been curtailed by the war exigencies, the Report now issued would have been of much greater compass. Quite a number of committees were in suspense.

Means were also restricted, of course. Instead of the usual 1,000*l.* or so available for research, last year's research grants came up to 268*l.* only. To this sum have to be added some allocations from the 10,000*l.* which Sir J. K. Caird placed at the unconditional disposal of the British Association in 1912, and which he later supplemented by a gift of 1,000*l.* to be devoted to the study of radio-activity. From these funds the following annual allocations were made in 1918: 50*l.* (instead of the former 100*l.*) to the Zoological station at Naples; 100*l.* to the Seismological Committee; and 250*l.* for the Magnetic Re-Survey of the British Isles.

Seismological Investigations.

The report of the Committee on Seismological Investigations (chairman, Professor H. H. Turner, F.R.S., of Oxford; secretary, Mr. J. J. Shaw, of West Bromwich) is drawn up by Professor Turner. It is gratifying that, in addition to the 100*l.* grant mentioned above, the Royal Society voted an allowance of 200*l.* from the Government Grant Fund. On the other hand, the staff at Shide, Isle of Wight, has lost the services of Mr. J. H. Burgess, Dr. John Milne's assistant, who, on the death of his chief in 1913, took charge of the station. Mr. Burgess had to leave the Isle of Wight for business reasons; Mr. S. W. Pring remains there, together with Miss Caws, who was trained by Mr. Burgess, and with Miss Bellamy; the latter was to return to Oxford, where one of the Milne-Shaw seismographs was to be set up in the basement of the Clarendon Observatory, in which Mr. Vernon Boys had made his gravity determinations. Meanwhile the establishment of a Geophysical Institute to comprise Geodesy, Seismology and Tides, has been decided upon, and the question, whether Oxford is to be the centre of this new organisation, and whether the basement just mentioned will answer as a seismological station, will probably come up for discussion at Bournemouth.

As regards the work at Shide, Professor Turner mentions that a dug-out, constructed for military purposes a few miles from Shide, was offered, towards the end of 1917, to Mr. Burgess, who remounted one of the Milne-Burgess instruments in this dug-out in which pumps had to be kept going to prevent flooding. The wandering of the trace of these instruments, to which we have referred in several previous reports, has not yet been satisfactorily explained; temperature variations are to a certain extent responsible, but it would appear that the wetting and drying of the ground, setting up movements in opposite directions, is the more direct cause.

The main portion of the report deals with the very difficult and laborious work of disentangling the corrections to the adopted tables from the errors to which they are subject. Especially at outlying stations the ignorance of clock errors causes considerable difficulties. But the general difficulty is the determination of the interval between the S and P periods on the seismograms. If we had two stations, A and Z, at the end of a diameter of the Earth, and the epicentre E of an earthquake half-way between the two, then the distance E A = E Z = 90 deg. should correspond to the table value S − P = 658 seconds. Professor Turner suggests that this value should be reduced by 17 seconds, to 641 seconds. In actual observations some groups of stations available will have to be substituted for A and Z, and the Z group may altogether be wanting, since most of the stations are situated in the northern hemisphere. Further, the reflected waves have to be considered, and there are many variable elements. Thus, though Professor Turner's results show possibilities, they are so far incomplete.

Impact Tests.

The Committee on "The Standardisation of Impact Tests," consisting of Professor W. H. Warren (chairman), Mr. J. Vicars (secretary), Professor Payne and Mr. E. H. Saniter, presents a first report. This Committee was appointed at the Australian meeting in 1914. Professor Warren is at Sydney, Professor Payne at Melbourne, it should be pointed out, and there is no information as to the locality where the tests were conducted, nor as to the source of the specimens. The report deals with tests of various steels (carbon, vanadium-chrome, nickel-chrome, nickel steels) performed with a Guillery machine (a fly-wheel, 21 in. diameter, carrying a knife with striking edge of 2 mm. radius); a Charpy pendulum hammer (maximum fall 1·42 m., maximum capacity 32 kgm., striking edge of pendulum 2 mm. radius, supports 40 mm. apart and not rounded, for test-pieces of 60 mm. by 10 mm. by 10 mm.); and a Martin's fall hammer, fitted with an Amsler recording drum apparatus, the drum of which is turned by an electric motor. In this last machine the committee made use of hammers of 30 kg. and of 12 kg. respectively, for steels of high or low resilience; the test pieces, of 160 mm. by 20 mm. by 20 mm., or 160 mm. by 30 mm. by 30 mm., are supported on steel castings of special design, spaced 120 mm. apart with edges rounded to a radius of 2 mm. In order to determine the relation between the ordinary static tension test and the impact tension tests, the committee adopted the method of P. Welikhow, of Moscow. By means of a calibrated spring the value of the energy due to a certain fall is first determined; a standard testing piece is then placed in the shackles of the machine, resting upon a weaker calibrated spring, and the compression of this spring is noted. This represents the kinetic energy remaining in the hammer after rupture of the test-piece. Subject to corrections the energy required to break the specimen would then be the energy of the hammer found by the first test, less the work absorbed by the second spring. The static and impact tests values obtained with three steels (soft, hard, extra hard) were found to be in fair agreement as to breaking load, elongation and contraction; the energy in rupture was greater in the case of the impact tests. The Charpy machine appeared especially suitable for brittle materials, the Guillery machine for tough steels. The shell steels proved much less homogeneous than the others, and of lower resilience, but gave on the whole good static and impact test figures, and there was nothing to suggest brittleness except the coarse crystalline structure, while the toughness and high resilience of the other steels was suggested only by their larger contraction of area of rupture and their fine silky structure.

Colloid Chemistry and its Applications.

The second report of the Committee on "Colloid Chemistry and its General and Industrial Applications" is, with its 172 pages, longer than all the other reports (which together take up 106 pages) and longer than last year's first report, a testimony to the recognition of the importance of the subject. Professor F. G. Donnan, F.R.S., is chairman of the committee, and Professor W. C. McC. Lewis, of the Muspratt Laboratory, Liverpool University, is the secretary. As in the previous report the 11 contributions by various authors are classified both as to theoretical considerations and to general applications. A third report is to deal with subjects not yet discussed, particularly also with special technical processes, and we hope that it will further provide something like a general summary and co-ordination of the complex phenomena. If so far some of the many writers on colloids seem to lose themselves in details, we can only surmise that the subject is not yet ripe for generalisation.

There is no doubt that the various contributors to this report have conscientiously studied their matter. But Professor Wilder D. Bancroft, of Cornell University, Ithaca, New York, does not make a very propitious beginning in the first paper of the report on "Peptisation and Precipitation" when he speaks in his fourth line of "tentative theories of peptisation by Lottermoser and others" without stating there—or anywhere else, so far as we can see—what he understands by peptisation.

We believe that the term peptisation or peptonisation is used to indicate conditions which for some reason prevent the colloidal particles from coalescing and being precipitated. If authors would make their own meaning clearer, there might be fewer tentative theories. Mr. Emil Hatschek, of the Sir John Cass Technical Institute, E.C., very properly opens his report on "Emulsions," the second paper, by stating: "The term emulsion is used to denote a disperse system both phases of which, *considered in bulk and at ordinary temperature*, are liquid. The qualifying clause [the italics are his], although not generally stated in such explicit terms, seems desirable as, on the one hand, the distinction between liquid and solid becomes somewhat vague with particles approaching ultramicroscopic dimensions, while on the other, the same system, *e.g.*, rosin in water, may be a suspension at lower temperature, and an emulsion at higher temperatures." Such a definition clears the ground. Dealing in the third paper with "The Liesegang Phenomenon," Mr. Hatschek starts with a description of the phenomenon: a glass plate is coated with a gel, gelatin containing a small amount of potassium dichromate; a drop of strong silver nitrate is placed on the gel; it diffuses into the gel, and a series of concentric rings are formed, at increasing distances apart, in which the brownish silver dichromate is precipitated. Why the silver salt does not spread in a continuous zone, but is discontinuously precipitated, is not fully yet understood, in spite of several theories. That is Mr. Hatschek's conclusion.

In the next two papers, Mr. T. R. Briggs, of Cornell University, deals with "Electrical Endos-

mose" from the theoretical and technical standpoints. He also starts, we are glad to see, with definitions, pointing out that since the days of Reuss, 1808, a flow of the liquid through the porous diaphragm of an electrolytic cell (electric endosmose) has frequently been confounded with the movement of suspended particles (cataphoresis); either movement may be with or against the current. Discussing the various theories, Briggs inclines to the view of Freundlich and Bancroft, who ascribe electric endosmose to selective adsorption of the ions. The industrial applications discussed, largely the processes of the late Botho von Schwerin, comprise dehydration (de-watering, Mr. Briggs writes) of peat, &c., clay purification, electric tanning, timber impregnation, electro-therapeutics. New to our columns is the Dawkins electric-endosmotic process of lubricating the metal of brick presses to prevent the adhesion of the clay to the metal. Water itself seems to be the cheapest and best lubricant; Briggs suggests that it is not the formation of hydrogen bubbles, but directly the endomosmotic wetting of the metal with water which prevents the adhesion.

In the other parts of the report Mr. W. Harrison, of Leeds University, deals with "Colloid Chemistry in the Textile Industry"; a very wide subject; Dr. E. J. Russell, of Rothamsted, with the "Part played by Colloids in Agricultural Phenomena," a study which may revolutionise scientific agriculture; Mr. E. Ardern, of Manchester, with "Sewage Purification and Colloidal Chemistry"; Mr. W. Clayton, M.Sc., of the Calders Margarine Company, Liverpool, with "Colloid Problems in Dairy Chemistry"; Professor W. M. Bayliss, F.R.S., with "Colloid Chemistry in Physiology," an article which might just as well have been put in the first, theoretical division; and Mr. A. B. Searle, of Sheffield, finally, with "The Administration of Colloids in Disease"—all subjects of great and increasing importance.

Of the remaining reports we mention those on Plant Pathology (Professor M. C. Potter, chairman, and Miss E. N. Thomas, D.Sc., secretary), drawing attention to the deplorable lack of adequate provision made in this country for training, research and correlation in plant pathology in spite of the ravages done to fruit, cereals, fodder and vegetables by disease and insect pests; and a report from the Educational Section on "The Free Place System and its Effects upon Secondary Education." Mr. C. A. Buckmaster, M.A., of Mill Hill College, is chairman, and Mr. Douglas Berridge, M.A., of Malvern College, secretary of this committee. The free-place system, we read, is a name given to an arrangement by which, in return for certain State grants administered by the Board of Education, secondary schools, working in connection with the Board, offer a certain number of places in the schools, free of all tuition fees, to pupils who have had at least two years' previous education in public elementary schools. The ostensible object of this grant is to offer facilities for secondary education to boys and girls whose parents could not afford to pay secondary school fees. The determination of the question as to who should be helped on the ground of poverty being beset with difficulties, it was assumed that all parents sending their children to public elementary schools might legitimately be considered to be in need of assistance. Since 1907 a certain proportion of free places has hence been reserved for pupils from these schools. The result has been the same as with many other scholarships founded to assist those really devoid of means. There have been complaints that the admission of free-placers has lowered the social status of schools to which they were admitted, and other parents have withdrawn their children. Although the report states that this class-exclusiveness is not to be regarded as a serious obstacle to the development of the system, the committee recommend that the free-place system should be available for all classes of the community. Dr. C. H. Bothamley, of the Somerset County Council education section, alone among the members of the committee dissents from this recommendation, which goes to the very root of the system. About the other recommendations, as to a minimum age limit of the children (twelve years), provision of meals and of grants for them, and the withdrawal of the privileges from lazy and incompetent pupils, the members of the committee were unanimous. The remodelling of the secondary education of the country will probably affect these questions as well as other problems.

We have not in our usual British Association reports, dwelt upon the proceedings of the Committee of the Corresponding Societies. We might add, however, that the paper on "Afforestation" which Mr. Martin C. Duchesne brought before the Conference of Delegates, over which Dr. F. A. Bather presided last year, gave rise to an instructive discussion.

IMAGINATION AND MECHANISM.

The faculty of mind termed imagination is apt to be scornfully regarded by the severely practical individual. Like faith, imagination is self-evident by inference and is everywhere accepted, if not mentioned by name. Both imagination and faith play a prominent part in the most practical affairs; especially in things mechanical and commercial. Indeed, so potent is the faculty of imagination that it is very doubtful whether reason itself is more important in its effects.

Simple fault-finding is not criticism, and the visionary dreamer, though imaginative, is not the type to imitate, both criticism and imagination to be of value must be constructive; that is, they must have a basis of practice on which to build. The difference between the typical wild inventor and the cautious practical man is a regard on the part of the latter for things as they actually exist and are. The one visualises without any practical basis, the other having standards of comparison confines his fancy to the region of the probable and actual. It may safely be said that for considerable success in any technical capacity an imaginative mind is essential.

Imaginative faculty is at its fullest value when the work to be accomplished comprises something in advance of accepted practice with few, if any, precedents for guidance.

The individual in whom imagination is at lowest ebb generally has one outstanding merit, usually regarded as a virtue. This is regard for the actual and literal truth. Many men incapable of a lie are virtuous in this respect, due to inherent inability to imagine a falsehood. Telling a real whopper in a convincing manner is an art to which verisimilitude can only be given by an acute imagination. Such an acquirement indicates an intelligence which in a proper field of effort might hope to achieve more than simple deceit. An artistic falsehood is misapplied imaginative energy which, properly used, would be a possession of real value. Such individuals are sometimes so constituted that it is impossible to get an exact and literal version of anything whatever from them. They must invert, embroider and exaggerate all that affects their consciousness. To be mentally incapable of a lie shows only that there is a lack of one of the most valuable mental characteristics; and regard for the truth in such instances cannot be accounted unto them for righteousness. George Washington was probably among this classification. Every idea, novel application, every revolutionary discovery, every design, piece of mechanism or simple job, must first exist as thought before it is expressed in metal. In other words, it must be imagined before it is materialised.

It is often worth while to take a manufactured article whose type and processes are fixed and seem immutable beyond question, and scheme out all the possible variants. The existing solution may be the best, the difficulties which impede the application of other methods may be insuperable, yet occasionally such a piece of analysis results in new ideas and alteration of process. For instance, in working out a new device the process is step by step, and it frequently happens quite unconsciously that a step vital enough in one connection is retained where substitution has rendered it unnecessary. Sometimes two processes can be combined with advantage, and cases where by rational alteration four distinct operations may be combined are not unknown. Original evolution required such division—working from the beginning they were justified but how often is the converse method of revision backward from the finish put into practice. This involution may, however, yield surprising results. Such exercise of the imaginative faculty is open to everyone associated with machine shop or constructional processes, and a development of mental power to solve fresh problems is the result.

Precedent is no end in itself, it is merely the limitation set by past practice which a few years of progress renders invalid and obsolete. Continuation along existing lines is easy, revision demands imagination and courage, but nothing survives for ever and periodical revision is merely a counsel of foresight and wisdom. It is the retention without reason of former practice which has led to failure and may indeed lead to national decadence in industry. In the interval between the fixation of practice and the present time, huge advances have been made elsewhere and the impossible of yesterday becomes the ordinary of to-day and the obsolete of to-morrow. Constructive criticism allied with imagination, with due regard to practical limitation, combined with a taste for experiment, make up a combination which provides against being in the rear of progress, and, in fact, places an industry in the front rank. In a more direct shop application the faculty of imagination plays an important part.

A capable foreman unconscious that he possessed imagination and probably scornful of such a term, gave proof of its possession when he explained his method of plotting out work. The shop was of a jobbing character with a large variety of work. His phrase "I never give out a job until I see it finished" revealed an imaginative bent. He actually meant that he visualised every operation in its entirety from start to finish, the men who would accomplish it, and how the operations on it would fit in with other work. In that shop no hitch ever occurred for which instant remedy was not forthcoming. Foresight is thus imagination in actual being. It is safe to say that no engineer of competent type lacks mechanical imagination, although in but few instances it is so termed.

THE LATE MR. ANDREW CARNEGIE.

We regret to have to announce the death, which occurred early on Monday morning, the 11th inst., at his summer residence, Lenox, Massachusetts, of Mr. Andrew Carnegie.

Andrew Carnegie was born on November 25, 1837, at Dunfermline, Scotland, and was the son of William Carnegie, a master handweaver who, upon the introduction of steam-driven machinery into the textile trade, found himself compelled to emigrate. He selected America as the most likely country to develop his activities, and together with his family settled in Pittsburgh in the year 1848. In the following year, his son, Andrew Carnegie, then only twelve years of age, started work as a bobbin boy at a wage of 1.20 dols. per week in the cotton mill in which his father worked at the loom. All the education he had received until then, apart from a short period spent at a day school, had been imparted to him by his mother; he had no time for further schooling for the next eighteen years or so, when he found the opportunity of attending courses in New York. A few months after he had entered the cotton mill, having learned to stoke a boiler and to run a steam engine in a small factory, he became an engineman, a duty which he subsequently combined with that of clerk to his employer. At the age of 14, he entered as a messenger boy the offices of the Ohio Telegraph Company, at a wage of 2.50 dols. per week; he there eagerly seized the opportunity of learning the telegraph code, an accomplishment in which he soon became highly proficient, this leading him to be selected for a post of telegraph clerk, first with the Ohio Telegraph Company, then with the Pennsylvania Railroad Company. His intellectual qualities, his ability and scrupulous attention to duty soon attracted the attention of the superintendent of the railroad company, Mr. T. A. Scott, who gave him a post in his department at the company's headquarters at a commencing salary of 35 dols. per month. Mr. Carnegie remained at this post, being practically the private secretary to Mr. Scott, for a period of thirteen years, and when Mr. Scott became vice-president of the concern, Mr. Carnegie was appointed

by him, superintendent of the Western (Pittsburgh) Division of the railroad.

Mr. Carnegie has related that at this period of his life, whilst travelling in a train he was approached by a gentleman (Mr. Woodruff), who showed him a model of a sleeping car which he had invented. Mr. Carnegie was so struck with the value of the invention and with its possible future that he invited Mr. Woodruff to Altoona to show the model to Mr. Scott. The latter immediately decided to place two trial cars upon the Pennsylvania Railroad, and a company was formed for the construction of sleeping cars, the Woodruff Sleeping Car Company, in which Mr. Carnegie accepted an interest. The company was ultimately absorbed by the Pullman Company.

In 1861, the American Civil War broke out, and Mr. Carnegie was placed in charge by his chief, Mr. T. A. Scott, then Colonel and Assistant Secretary for War, of the military railroads and telegraphs of the Federal Government, and in the course of this service he was present at the battle of Bull Run and other engagements.

A few years later, he purchased an interest in the Storey Farm, on Oil Creek, Pennsylvania, a venture which proved a financial success. His inclination, aided by his early training, his keen insight and the tremendous industrial activity which was commencing in the district in which his life had been cast, had, however, always been towards mechanics and metallurgy, and after one or two other ventures he resigned his position with the Pennsylvania Railroad and entered as a partner the Keystone Bridge Works Company—a company which he was largely instrumental in founding—at a time when wooden bridges were almost exclusively used on railways and when the Pennsylvania Railroad Company was experimenting with a type of bridge built of cast-iron. The Keystone Works built the first iron bridge over the Ohio River, a bridge having a 300-ft. span. Mr. Carnegie had founded, a few months previously, together with several of his young friends, the Union Iron Mills Company, a company which at first had but indifferent success. He, however, kept the company going as best he could, experiencing great difficulty for many months; he ultimately bought out the senior partner under favourable conditions, and the remaining partners superintended manufacture whilst he canvassed personally for orders for bridge and structural work to be built at the Keystone Company, the necessary material for which was rolled at the Union Iron Mills. His perseverance was not long in earning its reward, for owing to the great development in railway and bridge construction throughout the States following immediately upon the close of the American Civil War, the business of both concerns extended rapidly. With a view to provide them with an independent source of pig-iron supply, he decided to add blast furnaces to the plant, when the Lucy Furnace Company was formed, the first blast furnace of this firm being started to work in the early 'seventies of last century.

Mr. Carnegie had followed with the greatest attention and the keenest interest Sir Henry Bessemer's invention for the manufacture of steel, and with the acumen which was always one of his marked characteristics, he very early in the day arrived at the conclusion that steel was the metal of the future, that it would very soon supersede iron in all work connected with railways, the destination with which he was then, in the early 'seventies of last century, mainly connected. He took up the manufacture of steel by the Bessemer process when this process was in its infancy, and put down subsequently open-hearth furnaces, the three main works, the Homestead, Edgar-Thomson and Duquesne works being the principal of the series. These three works, according to the latest reports, owned 17 blast furnaces, 4 Bessemer converters, 111 open-hearth furnaces and 1 electric steel furnace, 10 blooming, large billet and slabbing mills, 2 small billet or steel bar mills, 4 rail mills, 19 other rolling mills, 1 bridge and structural plant, 2 foundries, 1 armour-plate plant, &c.

Besides these three main works, there are 27 others put down by the Carnegie Steel Company in different parts of the States, for the manufacture of pig-iron, steel, bars and sections, wheels, and steel and iron products of all kinds, the total plant owned comprising 51 blast furnaces, 14 Bessemer converters, 133 open-hearth furnaces and over 100 different rolling mills. These works have formed part of the United States Steel Corporation since early in 1901, when Mr. Carnegie retired from active business.

Mr. Carnegie became a member of the Iron and Steel Institute in 1879. He was elected member of council in 1890 and vice-president in 1896. He was president of that body during the two years from 1903 to 1905. During his presidency, in 1904, he was awarded the Bessemer medal; it was presented to him at the time of the American meeting of the Institute by Lord Airedale (then Sir James Kitson) who said that in Mr. Carnegie one could see a man with the sagacity to control the sources of iron and steel. He had been instrumental in turning these raw materials into products which were marketable, and had distributed them amongst the markets of the world. His great knowledge of the human machine had brought about results which had surprised mankind, and he had always looked for inventions which would advance the utility of the natural products of the earth.

Mr. Carnegie presented to the Institute in 1901 a sum which he, later on, increased to 100,000 dols., to form a Research Fund from which grants in aid of research work are awarded annually on the recommendation of the council. When the council consider the report detailing the results of the research to be of sufficient merit, the Andrew Carnegie gold medal is to be awarded to its author.

Mr. Carnegie had among many other talents, that of estimating almost at a glance the real efficiency of a man; he then retained his services and acknowledged them to the full. In this way, throughout the years of his business activity he gradually surrounded himself with a numerous company of experts in all branches of industry, experts who were devoted to him personally and to his manifold undertakings. This, indeed, coupled with his far-sightedness in rapidly recognising the real value of new processes and inventions, and the chances offered by new markets, is one of the secrets of his success, especially perhaps in later years, when by his indomitable energy he had laid the foundations of the various works which for decades have traded under his name in all parts of the world. The case may be put as follows, using Mr. Carnegie's own words. He was asked one day what would happen should his works be destroyed by fire, or should he suddenly lose all his material wealth, and he replied: "If I had my organisation intact, I could regain it all in ten years."

We need not speak here of his philanthropy and his gifts to different causes; all these are well known everywhere. By far the most important part of his life's work was the putting down of a whole series of metallurgical establishments which have formed and continue to be one of the United States' greatest assets.

Mr. Carnegie was at one time Lord Rector of St. Andrew's and other Scottish Universities; he received the degree of LL.D from Cambridge University in 1905, and was appointed a Commander of the French Legion of Honour in 1907. He had also received in the course of his life the freedom of a large number of Cities throughout the United Kingdom. He was the author of several books, among which may be mentioned "Round the World" published in 1879, and enlarged in following years; "Triumphant Democracy"; and "Problems of To-Day."

COAL RESEARCH IN GERMANY.

THE work of Professor Franz Fischer, Director of the German Coal Research Institute (Kaiser-Wilhelm-Institut für Kohlenforschung) at Mülheim-Ruhr is well known, especially since the Institute decided to publish annually collections of selected papers on the work carried out. The third volume* of these papers dealing with the research undertaken in 1918 has just been published, vol. i (1915-16) and vol. ii (1917) appeared some time ago. All three volumes contain papers which for the most part, have not previously appeared in any journal, although Fischer, together with his collaborator, W. Gluud, has occasionally published in the *Berichte* details of some of his investigations. For instance, in connection with the chemical composition of coal, Fischer and Gluud (*Ber. deut. chem. Gesellschaft*, 1916, 49, 1472) found that by suspending coal in water through which ozone is passed, the coal is gradually dissolved, forming a dark brown solution of a substance which has the smell of caramel and a pronounced acid taste. The work of the same authors on the extraction of coal with benzene under high pressure is briefly described by Professor Bone in his recently published book on "Coal and its Scientific Uses." Most of the paper in Vol. III, just published by the Institute at Mulheim, deal with low temperature coking and investigations carried out with low temperature tar or "Urteer," as Fischer proposes to call it. Other Papers treat of the distillation of coal with dilute alkali at high temperature (*e.g.*, No. 21), and under high pressure with other solvents than benzene (No. 22). Among other papers in the collection are (12) "Benzene Production from Brown Coal by Destructive Distillation," (25) "Heating Cellulose Under Pressure with Benzene," (26) "Pressure Extraction of Vegetable Matter with Dry and Wet Benzene," (27) "Effect of Water-content of Brown Coal on the Yields from Soxhlet Benzene Extraction and Benzene Extraction under Pressure."

In a recent issue of the *Berichte der deut. chem. Ges.*, 52, 1035-1068 (June 14, 1919) there are three further papers by Fischer and Gluud which, although written in 1917, have only just been published, and have not been included in Vol. II of the Institute's collected papers which deal chiefly with brown coal or lignite. In fact, lignite research has bulked very largely in the work on the Institute during the last two or three years.

The first of the three papers in the *Berichte* describes a new method of low temperature coking or distillation. The primary products of low temperature distillation of coal are napthenes highly viscous oils and solid paraffin; ordinary coal tar is not a primary product, but results from the decomposition, at higher temperatures, of the primary products. The percentage of alkali-soluble compounds will vary with the oxygen content, and may be as high as 50 per cent. or more in any of the fractions; and although the exact chemical composition of the low temperature tar is not yet known, it can safely be said that it approaches much more nearly to that of crude petroleum than to that of ordinary coal tar. Different methods of dry distillation yields very different tars, owing to low heat-conductivity of coal, but in every case when the products of low temperature distillation are required it is of course necessary to work with thin layers of coal, and to remove and cool the distillates quickly, to avoid exposure to volatilisation temperatures. This has proved very difficult on a large scale with rapid working. Fischer observes incidentally that a method of overcoming this difficulty was tried in the coalite process in England, but was abandoned. He himself used a cylindrical slowly-rotating iron vessel, into which the pulverised coal was introduced. The vessel rotates on a hollow shaft blocked in the middle, the left half containing inlets for the steam, and the right half outlets for the steam and distillates which pass through a vertical pipe into a heated iron vessel, where any dust or pitch collect. Thence, the hot vapours pass into a cooler, the tar oil being drawn off from below whilst the gasses escape by a side outlet. The apparatus is described and illustrated in detail, and suffices for treating 20 kg. of coal in one or two hours. An improved type of apparatus was subsequently described in Vol. III of the Institute's "Collected Papers" (1918, page 253).

The second paper in the *Berichte*, by W. Gluud, treats of paraffin from coal, its chemical composition, fractional distillation and isolation of hexakosane, heptakosane, and octakosane. The most important result claimed for this part of the work is that coal can be made to yield very considerable quantities of light hydrocarbons (benzine) hitherto obtained almost exclusively from mineral oils; and that, in the low temperature distillation of coal, benzine, similar to that obtained from petroleum, is

* By Verlag von Gebruder Borntträger, of Berlin, price 26 marks.

produced instead of benzene (benzol) which is found either in very small quantities or not at all. This corresponds with the results obtained by Jones and Wheeler in the vacuum distillation of coal. These light hydrocarbons, boiling-point 20 deg. to 200 deg., are recoverable to the extent of about 1 per cent. of the weight of the coal, so that, as Fischer and Gluud point out, very considerable quantities of these products are available.

Coal benzine is more fully investigated in the third paper. The low-boiling fractions (20 deg. to 200 deg.) are water-clear, or slightly yellow, according as they are near the lower or higher end of the series, and the smell likewise varies in the same order from that of benzine to petroleum. The usual methods of purification, namely, with concentrated sulphuric acid and 15 per cent. fuming sulphuric acid, gave good results. The use of aluminium chloride, as recommended by Heusler for benzol, was also tried and found very successful. In this case, however, there is a certain evolution of heat, and with the lower boiling fractions, at all events, it is necessary to water-cool. The results of purifying and of subsequent distillation are given in table from which the following conclusions may be deduced:—The first fraction (20 deg. to 60 deg.) consists of saturated hydrocarbons of the paraffin group, probably pentane or hexane. Fraction 60 deg. to 100 deg. from analysis consists chiefly of napthenes, but the typical representative of the low-boiling coal distillates in ordinary tar, benzene, is almost entirely absent. The constitution of the next two fractions (100 deg. to 125 deg. and 125 deg. to 190 deg.) is uncertain; they may consist almost entirely of terpenes or a mixture of paraffins and napthenes. In the latter case it should be possible by further purification to obtain lighter bodies from this fraction, and this was accordingly confirmed after purifying with aluminium chloride. Very thorough and elaborate tests were made with the fraction 60 deg. to 100 deg. to discover the presence of benzol. The result was negative. Results of some practical interest and importance were obtained from the cold-resistance tests. The lower fractions remained unaltered at temperatures ranging from — 80 deg. to — 135 deg., whilst the higher fractions (100 deg. to 190 deg.) remained unaltered at — 60 deg. to — 90 deg.

In a German review of the three volumes of "Collected Researches" it is stated, *inter alia*, that there are altogether 62 papers, of which a few deal with the production of ammonia in dry distillation, but most of them with low-temperature distillation and low-temperature tar (Urteer). The research is not limited to ordinary anthracite coal, but includes also lignite, cellulose and wood, the liquefaction of naphthaline, the hydrogenation of coal, the production of acetylene, methane and other hydrocarbons, and, in fact, the whole field of coal distillation. In the reviewer's opinion the three most important papers in Vol. III treat of the behaviour, under low-temperature distillation, of the coals of Upper Silesia, Westphalia, and the Saar district. Those dealing with phenols, benzine, solar oil, &c., are also of special interest. The Institute has done very valuable work in the chemistry of coal and has proved of great assistance to German industry and technology. "The rational utilisation of coal must henceforth take the place of the suicidal waste which has hitherto prevailed."

It is of interest to note that another Coal Research Institute has just been established at Essen by the Gesellschaft für Kohlentechnik m.b.H. Its main policy will be rather commercial and industrial than purely scientific, the latter field being sufficiently covered by the older Institute at Mülheim.

NOTES.

The Development of the Electrical Industry.

Although in the near future the supply of electrical energy in this country may be profoundly modified by legislative action now contemplated, there appears to be no reason for checking the development of distribution systems, or restricting the demand for the supply of power, while awaiting the Government's action. Whether existing methods are superseded or not, the success of the industry as a whole must ultimately depend upon the increased use of electrical energy, and particularly upon its application to the greatest possible variety of industrial and domestic requirements. These, at all events, are the views of the Electrical Development Association, and few, we think, will take exception to them. This association has been formed on a co-operative basis by the Institution of Electrical Engineers and various bodies representing public and private supply undertakings, manufacturers of electrical machinery and appliances, and also electrical contractors, for the purpose of carrying out publicity and propaganda work on behalf of the electrical industry in general. Evidently much may be done in the direction of educating the public as to the economic possibilities and limitations of electricity. For instance attention has been largely drawn to the economies resulting from the centralisation of supply systems, but far less stress has been laid upon the equally important advantage to the consumer of increasing the load factor of the power station. By placing such matters before the public, and by generally directing public opinion in the right channels, the association will doubtless soon justify its existence by the resulting benefits to the industry. It will also call attention to developments in the industry as far as these affect the public service, act as a source of information for all parties interested in problems relating to the uses of electricity, and serve as a link between the various industrial interests concerned and the consumers of electrical energy. The present time is certainly favourable for a properly directed effort to be made to show the public how electricity may be used to assist in solving some of the many problems with which the industries of the country are now faced, and for this reason the association appears to be fully entitled to the support, which it invites, of all branches of electrical work.

Indian Imports of Metals and Machinery.

Iron and steel are India's largest imports after cotton piece-goods and sugar. But the total imports of iron and steel in the year 1917–18, according to the Review of the Trade of India, amounted to 152,000 tons, a decrease of 41 per cent. as compared with the preceding year, and of 79 per cent. as compared with the pre-war quinquennial average. The total for the year under review is made up of 76,800 tons from the United Kingdom, 62,700 tons from the United States, and 12,500 tons from other countries. The largest total reached in the imports of iron and steel was that for the year 1913–14, namely, 1,018,200 tons, of which 611,300 tons came from the United Kingdom, 200,100 tons from Germany, 171,000 tons from Belgium, 22,000 tons from the United States and 13,800 tons from other countries. The diminished imports were due to the impossibility of obtaining supplies, together with the resulting high prices and the use of substitutes. Corrugated sheets, for example, which in the pre-war quinquennium had the largest tonnage, 175,500 tons, dropped to 5,500 tons. When the price of corrugated sheet iron rose to a prohibitive level, recourse was had to the use of thatch for roofing purposes, and this has been found to be serviceable, durable, impervious to rain and cooler than corrugated iron. At the present time, when builders in Calcutta are unable to obtain structural material, such as beams, they not infrequently find themselves compelled to employ disused rails. Besides beams, there was a remarkable decrease in the imports of pillars, girders and bridgework. In regard to tin plates, there was an increase of 4 per cent. over the pre-war average, the quantity imported being 32,200 tons; this quantity, however, was 27 per cent. less than that for the preceding year. Nearly 22,000 tons came from the United Kingdom, and 9,000 tons from the United States. In sheets and plates, not galvanised or tinned, most of the business went, for the first time, to the United States. In the matter of railway plant and rolling-stock the year's imports on private and Government account decreased by 45 per cent. as compared with the preceding year. The total value of the trade in the year was only one-ninth of the pre-war quinquennial average. The imports of copper amounted to approximately 2,600 tons, as against 1,700 tons in the preceding year and 30,000 tons, the pre-war quinquennial average. The value of the total imports of machinery and millwork, including belting, showed a decrease of 13 per cent. as compared with the preceding year, the most noticeable decreases being in jute mill machinery, cotton-mill machinery, electrical, mining, and tea-garden machinery.

Crystalloluminescence and Triboluminescence.

When a solution of potassium sulphate in water is evaporated until crystals begin to form and is then poured off into another vessel and cooled slowly without agitation, flashes of bluish light are seen to shoot through the liquid while it turns into a mass of crystals. More striking still is the phenomenon when arsenic acid is dissolved in hydrochloric acid, and the solution is placed in a freezing mixture at —5 deg. C.; as soon as sparks appear, the crystals fall out rapidly. Another way of performing such experiments is to add hydrochloric acid to a solution of sodium chloride; the precipitation of the salt is associated with a luminescence. This is known as crystalloluminescence, and is not a rare phenomenon; it is shown by the bromide and iodide of potassium, *e.g.*, not by the same sodium salts, however. Triboluminescence is the luminescence observed when crystals are crushed or split and is also fairly common. In this latter case the suggestion, made in 1820 already by Henrich, that the sparking is due to frictional electricity, seems very plausible. But there are other explanatory suggestions. Schneider rubbing diamonds together found no connection between frictional electricity and tribo-electricity; W. J. Pope could not establish any connection of triboluminescence with pyro-electricity; others considered the phenomena as thermal or chemical; Trautz observed that freshly-prepared crystals lose their triboluminescence with age. The suggestion of chemi-luminescence has recently found an advocate in Professor Harry B. Weiser, of Houston, Texas (Journal of Physical Chemisty, October and November, 1918). Weiser points out that amorphous as well as crystallised substances may be triboluminescent, and that the disturbed crystal symmetry of some scientists is not essential to the phenomena; that may be, but the argument would not disprove the electric character of triboluminescence. Weiser, however, considers with Bancroft crystalloluminescence as a special case of triboluminescence and both due to chemical action. In his opinion the two phenomena, which are usually associated, go together with conditions favouring a high concentration of ions in excess of the equilibrium ionisation; most luminescent substances are also dissociated in these solutions. The addition of a colloid like gelatin diminishes the luminescences, not because it increases the viscosity, but, he argues, because it interferes with the dissociation, cane sugar has little effect on the luminescence, though it also increases the viscosity. Weiser supports this argument by novel spectroscopic observations. The light emitted is too faint for direct spectrometry. By passing the faint light through various colour filters, he ascertains, however, that in the case of the arsenic acid experiment, which we mentioned above, the light emitted contains neither red, nor yellow and very little green, being essentially blue; the same colour he observes in triboluminescent arsenic acid, and when burning arsenic in oxygen or when feeding arsenic compounds into coal gas or hydrogen flames. He made similar colour observations with potassium sulphate. These experiments are certainly interesting, but they can hardly be said to afford much support to the hypothesis that the tribo- and crystalloluminescences are due to chemical action, and to the recombination, rather than to the decomposition, of the atoms. Ionisation may play an important part; but so far as we are aware attempts to prove that liberation of electricity accompanies chemical combination have not been successful, and something like that seems to be involved in Weiser's suggestion.

Non-Ferrous Metals.—The following particulars are published of the stocks, exclusive of old metal and scrap, in this country in possession of the Minister of Munitions on the 1st inst.: Copper, 37,230 tons; spelter, G.O.B., 23,168 tons; spelter, refined, 12,136 tons; aluminium, 10,500 tons; soft pig lead, 108,010 tons; nickel, 2,452 tons; antimony regulus, 4,411 tons.

LITERATURE.

A Treatise on Roads and Pavements. By IRA OSBORN BAKER, C.E., D.Eng., Professor of Civil Engineering, University of Illinois, 1918. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 19s..]

THIS is the third edition of a work originally published in 1903, but owing to the changes and improvements introduced into the methods of road and pavement construction it has been submitted to very considerable revision. With the change in the amount and character of vehicular traffic, modern practice of construction has altered to such an extent, that it has been found convenient to suppress whole chapters and to substitute new material, better suited to the needs of road surveyors and highway engineers. A good many factors, perhaps we should say interests, enter in the construction of a new road, as the choice of routes, the topography of the district, the probable growth and direction of traffic, the possibilities of drainage, the proximity of suitable material for road-making, with other considerations, and the author apparently considers that a wide and instructed view would be of benefit to the public. Hence the purpose of the treatise is to show that the science of road construction and maintenance is based upon well-established elementary principles that can be easily grasped, and that the art depends upon correct reasoning from the principles, rather than in attempting to follow rules or tried experience. He does not approve the suggestion that better or more economically constructed roads would result from giving engineers absolute control of the roads and highways. There is no evidence, according to Professor Baker, "that any considerable number of engineers comprehend either the principles of road-making necessary for the improvement and maintenance of our country roads or the economic limitations and political difficulties of the problem." In this country that opinion is not generally held, there is a growing feeling that our universities should adopt a policy more in union with the American universities and institute special courses of lectures on highway engineering, with the view apparently of obtaining trained specialists.

A vast and not thickly inhabited country requires long roads, over which little traffic will be carried per mile, and these will necessarily be made in the easiest and cheapest manner, for it is only when road traffic becomes considerable that it is possible to procure the money with which to improve the surface by the addition of foreign material, as gravel, or broken stone, pitch or bitumen. For this reason, by far the greater part of American roads are earth roads, that is, made of native earth, treated and drained so as to give solidity and firm wheelways. But such roads must evidently tend to disappear. Previous to 1903, the date of the first edition, 95 per cent. of the American roads were earth roads. In 1915, the percentage was reduced to 87, and in the author's opinion from 70 per cent. to 80 per cent. of the public highways will continue to be made of earth. It is difficult to accept this estimate, because the tendency of the time is to extend road traffic in order to ensure a more general distribution of goods to the consumer than is possible by railway. Tramways and narrow-gauge light railways have, in this country, at least, proved unsatisfactory for the collection and distribution of produce, because railway service stops at the point reached by the rails themselves, and fails to satisfy the claims of scattered clients over an extensive area. The dweller in the country or in the suburbs of large towns looks for accommodation not inferior to that supplied to the townsman. The difficulty of distribution to the individual is responsible for much objectionable overcrowding in cities, and the success of many of the schemes proposed as a remedy will depend much upon the provision of good and reliable service, to which well-constructed roads will contribute. The motor lorry is becoming a very useful adjunct or substitute for railway carriage, but such vehicles travelling at a greater speed than the horse-drawn wagon of the same weight, disintegrate the road surface more rapidly.

To a continually greater extent we are submitting the roads to a more severe strain than they were intended to meet. Reliable and recent statistics showing the gradual displacement of the horse-drawn vehicle by the mechanically-driven automobile are not forthcoming, but in one case quoted by the author, that of St. Louis, the total travel on certain business streets in 1914–15 increased 20 per cent., but while the increase in motor-driven traffic amounted to 53 per cent., the horse-driven declined 15 per cent. Some idea of the actual number of motor vehicles in use is shown by the fact that in 1916 there was an average of 1·4 motor cars for each mile of rural public roads in the United States, and this number is growing. The increase in 1915 was 40 per cent., and in 1916 43 per cent., above that of 1901. The several States charge a registration or licence fee, from which in 1916 a gross revenue of approximately 5,000,000*l.* was derived, and of this sum 92 per cent. was devoted to road improvements, but this subsidy was only about one-tenth of the country's expenditure on rural roads and bridges. From figures and tables set forth in Professor Baker's treatise, it seems doubtful whether the sum drawn from licences might not properly be increased. This certainly seems to be the opinion in America, "for the tendency in all the States is to increase the fee." In this country, and probably in the United States, though in a question of domestic policy we naturally speak with more reserve, much of the motor driven traffic is in competition with the railways, and these latter may be unduly handicapped by the necessary maintenance of their roadway and the payment of local rates and taxes, while the owner of the lorry has the use of the highway practically free for the collection and distribution of goods. He has no limiting scheduled rates to which he has strictly to adhere, but can make his charges according to what his trade will bear. Our provincial press, urged possibly by local interests, has insisted with such good effect that our public roadways have suffered severely during the war owing to the lack of labour and material, that the Government has granted a substantial subsidy for repairs, but it is probable that the altered character of the traffic has contributed in no small measure to the destruction of the road surface, warranting an increased charge on the goods carried by road.

Many statistics given by Professor Baker show that the cost of road-making and subsequent maintenance increase independently of such abnormal causes as the late war occasioned. From 1904 to 1915, the annual expenditure on road improvements increased more than 250 per cent. During the same period, the annual expenditure for State aided road and bridge construction and maintenance increased no less than twentyfold, while the local bond issue increased only eleven times. In 1904, the cost of road-making under State supervision was 6 per cent. of the total road expenses, but in 1915 it was 30 per cent. This increase is not to be explained simply by greater mileage; but the demand for better roads, more suitable for heavy traffic and of higher standard quality, enormously increased the cost of construction per mile. In 1904, the actual cost of new road and repairs did not amount to 28 dols. per mile. Eleven years later, the cost had risen to 109 dols. per mile. The total expenditure in 1915 was 267,000,000 dols., and there can be no doubt but that this sum will be rapidly and greatly augmented. The engineering profession and the public generally should be largely interested in a problem of such magnitude, but the author intimates that laxity and indifference characterise the attitude of mind of both the engineer and the normal taxpayer. Quoting with approval from a paper submitted to the Commercial Club of Chicago, he is inclined to divide this blameworthy unconcern fairly between the two. The engineer finds the representatives of the taxpayer an uninstructed and exacting body, incapable of initiating broad policies and distrustful of sound suggestion. We seem to have encountered that Road Committee "who postpones all possible trouble to its successors, and blames all deficiencies on to its predecessors, while ever pleading for revenue for new experiments." Censure is also impartially bestowed on the public, who indulge in expensive street pavements without systematic investigation of travel statistics, and do not compile reliable data from which may be computed the cost of maintenance, the length of life, or the rate of deterioration. Few cities exhibit "sufficient public spirit adequately to care for the investment after it is once made." It is to be hoped that such a book as the present will be effective in arousing public attention, overcoming prejudice, in making experiment more thorough and systematic, and in removing the stigma that "community after community repeats the fundamental experiments and copies without reflection or study what it sees being done elsewhere."

But though occasionally caprice may dictate the choice of a pavement, and ignorance select material ill adapted to particular requirements and environment, improvement goes on, if not so fast and so intelligently as experts could wish. Money may not always be spent wisely, but it is not spent niggardly. Taking all cities above 30,000 inhabitants, the pavements have cost some 696,000,000 dols., and as the total population of the same cities is about 25,500,000, the pavements in construction and maintenance have claimed, approximately, 27 dols. per capita. In cities having more than 100,000 population, the annual cost per head is 1¼ dols., but is naturally more in smaller towns. Street pavements are by far the most expensive single improvements that any municipality undertakes, and in importance rank next to railroads. This fact quite justifies the appearance of such a book as that under review.

Though it is impossible to refer to the technique of the subject, it is a pleasure to acknowledge the completeness of detail and the breadth of outlook shown in discussing the various methods of construction, that are suitable for different varieties of traffic, or may be adopted on sufficient grounds. Various kinds of road covering come under review, as hydraulic concrete, bituminous concrete, asphalt, brick, stone block, and wood block and if other materials or combinations, had been used extensively, they would have found a place here. It is important to notice that judged by every test, whenever a road covering is demonstrated to possess some improvement in a marked degree, that form is found to be displacing the earlier and cheaper varieties; the more progressive the community, the more rapid the displacement. Two-thirds of the asphalt pavements are in cities having a population of more than 300,000, and one-third of the whole amount is in New York City. Of creosoted wood block, whose initial cost is more than twice that of water-bound macadam, more than one-half is found in three industrial centres. From 1890 to 1909, the latest year for which extensive statistics are available, the area of pavements increased 38 per cent., and the cost 71 per cent. Although some of the extra expenditure is due to the higher cost of labour and material, the increase is mainly due to the general demand for a superior class of pavement. The percentage of asphalt covering, sheet and block, in 1890 was only 3·2 per cent., but rose, in 1901, to 13·6 per cent., and in 1909 to 21·6 per cent. On the other hand, cobble stone, objectionable on account of noise and for harbouring unhealthy conditions, decreased in the same three epochs from 15·1 per cent. to 6·8 per cent., and lastly 2·6 per cent. Water-bound gravel diminished from 31·0 per cent. to 14·7 per cent., and at the last date, 12·2 per cent. If later data had been available, it would probably have been found that cobble-stone pavements had practically disappeared, portland-cement concrete and bitulithic (otherwise bituminous concrete) would have increased, while much of the water-bound gravel and macadam pavement would be changed to bituminous bound. Some of the newer forms to be recommended as possessing a smooth surface, easily cleaned, noiseless, durable, yielding neither dust nor mud, do not appear in the earlier years, but put in a very reputable appearance at the latest date.

This progress is very satisfactory, and it is gratifying to note the increased interest that engineers are displaying in the means of promoting transport facilities. In one direction more information would have been desirable, but, unfortunately, is at present inaccessible. When a new pavement is put down, many of its qualities can

be determined in a few months, certainly its deficiencies become apparent, but the degree of durability, the probable life of a pavement can only be known by long and actual experience. Our Road Board has employed mechanical means for testing the wear of surfaces, but Professor Baker scarcely refers to any such kind of test. Some qualities would seem to be adequately tested by running loaded wheels over a circular track. The load upon each inch of width of tyre is usually about 470 lbs., and the whole machine is run at a rate of about 2,200 tons per yard of width per hour. The surface is not considered satisfactory that will not permit 200,000 tons, per yard of width, to be rolled over it without wave-like markings and corrugations making their appearance. It is true that this tests only one variable, the effect of uniform traffic. It may be objected that the durability of a perishable paving material, as macadam and asphalt, depends as much on climate as on traffic. Of less importance, but by no means negligible, are the width of the roadway, the position of tramlines and the character of the travel, that is the weight per unit width of tyre. Moreover, it must be remembered, that all pavements, however carefully constructed, wear most unevenly, and require relaying before the wearing coat is entirely worn out. For these and some other reasons, into which it is not necessary to enter, experiments on actually constructed roadway, submitted to ordinary traffic, appear to offer the only trustworthy evidence. Just as our Road Board has put experimental pieces of paving in juxtaposition, all of which will undergo the same variations of climate and traffic, so we learn that the State Highway Commission of Massachusetts has put down ten sections, each 500 ft. long, on Washington street, Boston. These test sections were originally designed to test slipperiness, and for this reason the materials employed are those generally used on rural and suburban roads, but, incidentally, it is expected that the experiment will demonstrate other points of interest. Unfortunately, like our London experience, a long time is required for the collection of trustworthy evidence.

BOOKS RECEIVED.

Factory Administration and Account. By Edward T. Elbourne. With contributions on *The General Problem of Industrial Works Design.* By Andrew Home Morton, M.Inst.C.E., M.I.Mech.E. and *Financial Accounts*, by John Maughling. New edition. London: Longmans, Green and Co. [Price, 37*s.* 6*d.* net.]

Electricity and the Motor Car. Lighting; Engine Starting, Ignition. Specially written for the amateur motorist. London: Iliffe and Sons, Limited. [Price 4*s.* 6*d.* net.]

Boiler Feed Water. A concise Handbook of Water for Boiler Feeding Purposes (its Effects, Treatment and Analysis). By Percy G. Jackson, F.I.C. London: Charles Griffin and Co., Limited.

From War to Work. By Samuel Turner. London: Nisbet and Co., Limited. [Price 2*s.* net.]

The Principles of Electric Wave Telegraphy and Telephony. By J. A. Fleming, M.A., D.Sc., F.R.S. Fourth Edition (revised). London: Longmans, Green and Co. [Price 42*s.* net.]

The Permanent Way Handbook. By Captain S. C. Clayton, C.E. (late R.E.). London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 6*s.* net.]

The Year-Book of Wireless Telegraphy and Telephony, 1919. London: The Wireless Press, Limited.

Smithsonian Institution, United States National Museum. Bulletin 102, Vol. I. *The Mineral Industries of the United States. The Energy Resources of the United States. A Field for Reconstruction.* By Chester G. Gilbert and Joseph E. Pogue. Washington: Government Printing Office.

Concrete-Steel Construction. Part I. *Buildings.* By Henry T. Eddy, C.E., Ph.D., and C. A. P. Turner, C.E. Second Edition, re-written and embodying the most advanced theoretical developments. Minneapolis: C. A. P. Turner Company.

Willing's Press Guide and Advertisers' Directory and Handbook. London: James Willing, Limited. [Price 2*s.*].

A Glossary of Aeronautical Terms. Prepared by the Technical Terms Committee of the Royal Aeronautical Society. Edited for the Council by Mr. W. Barnard Faraday, LL.B. London: The Royal Aeronautical Society. [Price 2*s.* 6*d.* net.]

Practical Shell Forging and the Plastic Deformation of Steel and its Heat Treatment. By Clifford O. Bower, A.M.Inst.C.E., A.M.I.Mech.E. London: The Library Press, Limited. [Price 30*s.* net.]

The Journal of the Institute of Metals. Vol. XXI. Edited by G. Shaw Scott, M.Sc., Secretary. London: Published by the Institute. [Price to non-members 31*s.* 6*d.*]

PLUG COCK FOR PETROL.

Although in comparison with the many intricate details of a modern motor car the small plug cock which controls the supply of petrol to the carburettor may seem a very insignificant item, it can, and frequently does, become a source of considerable annoyance to the motorist. When used with petrol, a plug cock of ordinary construction soon sticks owing to the fact that the grease, with which it is originally supplied, is dissolved, and this leads to scoring of the plug and body, and leakage follows as a matter of course. Efforts to reduce this leakage by knocking down the plug naturally cause it to jam completely, and, not infrequently, the handle is wrenched off in endeavouring to open or close the cock by means of a pair of pliers. Troubles of this character are obviously of greatly increased importance on aircraft, where fire resulting from petrol leakage is generally attended with fatal results. Cocks specially designed to avoid these troubles have therefore appeared, and one of these, designed and made by the Aviation Department of Messrs. Vickers, Limited, forms the subject of the present article.

The photograph reproduced in Fig. 1, annexed, shows the general appearance of the ¼-in. size, reduced in reproduction to about three-quarters of its actual dimensions, and its construction will

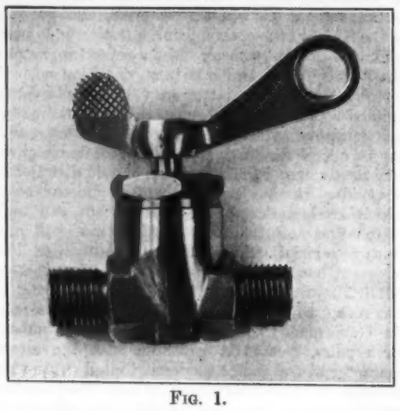


Fig. 1.

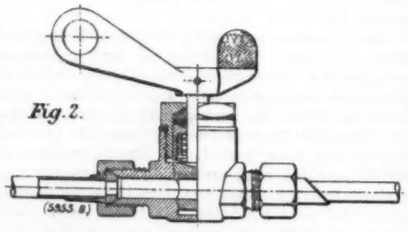


Fig. 2.

be clear from an inspection of the half-section and elevation given in Fig. 2. As will be seen, the cock is of the plug type, and the body, which is of gun-metal, is closed at the bottom, thus avoiding one source of leakage. The plug is made of stainless steel, hardened and ground to a perfect fit in the body, and formed with a cylindrical stem which passes out of the body through a spring-packed stuffing-box. The packing used is asbestos impregnated with graphite, neither of which materials is affected by petrol or by heat. The packing is pressed up to the plug stem by a helical spring, which bears, at one end, on the shoulder formed by the plug and, at the other end, on a packing ring which is free to slide in the gland; by exerting a uniform pressure on the plug the spring also tends to make the cock work smoothly. The joint between the gland and the body is made with string and gold size, or shellac, either of which has been found to be quite satisfactory for the purpose. The handle, which is of aluminium, is fitted and pinned on to a squared portion of the plug stem, and, as shown, is provided with a roughened thumb rest, which gives an excellent grip. Stainless steel seems to work extremely well with gun-metal, even without lubrication, and, being hard, it is not easily scored by grit in the petrol. The construction of the cock, however, permits the plug to be pulled up for a short distance, and thus allows any foreign matter that may have worked in between the plug and the body, to be washed away; the gland, of course, prevents any leakage of petrol during this operation.

One of these cocks, suitable for ⅜-in. piping, was recently tested in the Engine Section of the Air Ministry Laboratory, at Imperial College, and some of the results obtained are of interest. The hydraulic resistance of the Vickers' cock, for instance, was found to be less than that of a 4-ft. length of ⅜-in. piping, whereas that of another design of petrol-tight tap, tested at the same time, was more than 10 times as great. The weight of the Vickers' cock was also 12 per cent. less than that of the other design. The Vickers' cock was then tested for leakage and "through" tightness at a pressure of 10 lb. per square inch, and was found to be perfect in both respects after having been turned on and off 50 times, left running for 10 minutes, shut off for 10 minutes, turned on and off another 50 times, and finally tried with equal pressures on both sides of the cock. The pressure was then increased to 20 lb. per square inch, and a slight leakage round the gland was detected, but only sufficient petrol escaped to form a drop every 2 or 3 minutes; there was no "through" leakage in this, or any other, test. To test the endurance of the cock a pulley was then fitted in place of the handle, and the plug rotated continuously at 150 r.p.m. for 1 hour in one direction, and for another hour in the opposite direction. The pressure used in this test was 10 lb. per square inch and the small leakage, above referred to, continued during the first hour, but ceased as soon as the direction of rotation was reversed, and did not reappear. It may here be noted that, in this test, the cock would be opened and closed 72,000 times. After this, the first two tests at 10 lb. and 20 lb. per square inch, respectively, were repeated, and, in neither case, was leakage of any description detected. It reappeared, however, after the plug had been pulled out and sprung back several times in succession, but pressing the plug in firmly, and turning it a few times, was sufficient to prevent any further leakage at pressures lower than 20 lb. per square inch; at the latter pressure, however, a small leak could still be detected. In all cases the leakage was so slight that in a warm situation the petrol would probably have evaporated without forming a drop. It is, perhaps, hardly necessary to add that a pressure of 20 lb. per square inch is considerably higher than the cock would be subjected to in practice.

The cocks can be supplied in sizes suitable for pipes ranging from ⅛ in. to 1 in. bore, and with any type of pipe connection; they are also made, for special purposes, with three, or more, branches. In another form the handle is provided with a projecting part, which carries a spring pin, and this fits into recesses formed in the body in positions corresponding with the open and closed positions of the cock. With this arrangement the plug cannot be moved round by vibration. All cocks are tested before delivery and with petrol at a pressure of 10 lb. per square inch, and none is supplied unless the gland and plug are perfectly tight at this pressure.

Engineering Schemes in the Dutch East Indies.—According to the British Vice-Consul in Sourabaya, there are now many large water works schemes materialising—perhaps the most notable of which is the Batavia water supply. This scheme has been in contemplation for many years, but tenders have now been called for covering the first portion of the necessary pipe-lines, amounting to about 4,000 tons. The total quantity required will eventually amount to approximately 30,000 tons, and the cost of this work has been estimated at some 10,000,000 guilders. Smaller towns, also, are demanding water works. Some contracts have been given out, and others are delayed by various causes, but will no doubt materialise later on. Large schemes for the development of electric power, with high-tension transmission, are in progress or being worked out—one of which will develop as much as 30,000 h.p. There is undoubtedly a large future for all classes of electrical machinery. German competition has entirely ceased for the time being, and the natural suppliers will be Great Britain, America and Holland, where engineering facilities have been developed owing to the war. No effort should be spared by British manufacturers to capture their share of this important trade. Shipbuilding has also been started in the Dutch East Indies, and, with an increased supply of skilled labour, considerable development should take place. At present operations are confined to wooden hulls, but if a steel industry is started, as is contemplated, it is possible that a considerable amount of tonnage suitable for the island traffic will be constructed there. The one-day route between Batavia and Sourabaya will, in all probability, be an accomplished fact before the end of this year. If materials for railroads, bridges, &c., had been obtainable, it would no doubt have been finished last year. There is a very great shortage of rolling-stock, and heavy shipments are now ready for Holland. The absence of British rolling-stock is particularly noticeable, and every effort should be made to rectify this unsatisfactory state of affairs. On account of the impossibility of supplying sugar machinery during the war, the mills were forced to carry on with old machinery. This will mean very large renewals in the near future, due to exceptional wear and tear. Representatives of manufacturers of this class of goods should proceed to the Dutch East Indies prepared to submit full details, plans, prices, &c., when, no doubt, large orders could be obtained. Much could also be done by interviewing the agents of the mills in Holland. Considerable development is taking place with harbour works, and good progress is reported in Sourabaya and Macassar.

PATTERN-MAKING MACHINE.

CONSTRUCTED BY MESSRS. WADKIN AND CO., LEICESTER.

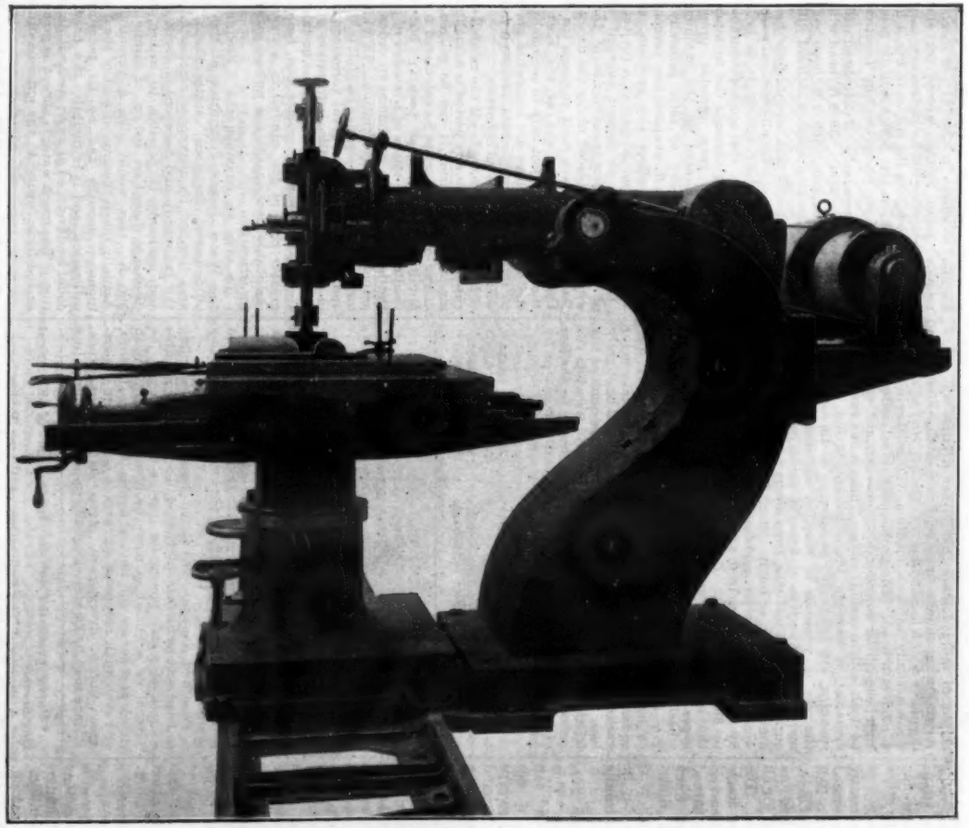


FIG. 3. MACHINE MAKING A PATTERN OF A BEND.

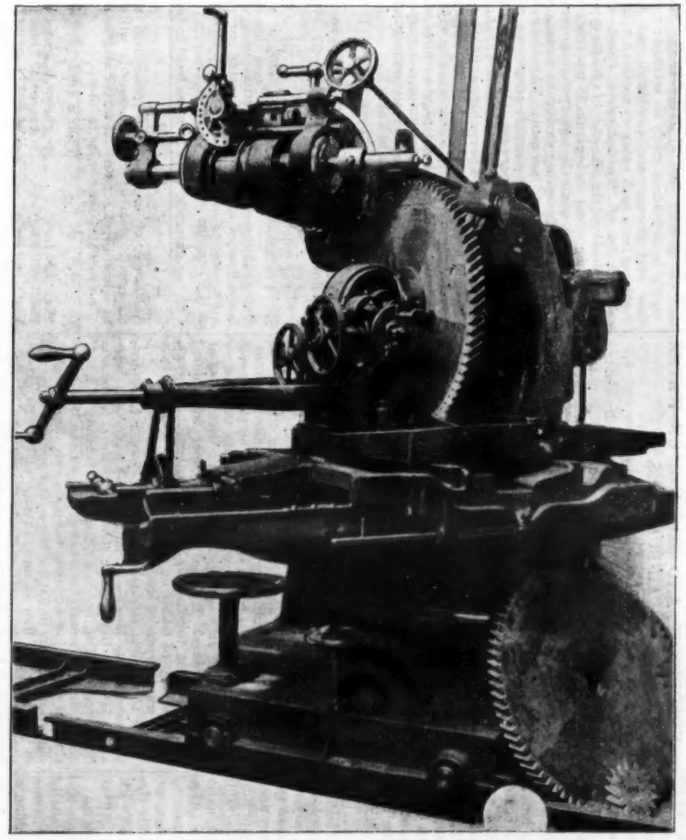


FIG. 4. MACHINE SET FOR CUTTING GEAR PATTERNS.

IT is an established fact that the pattern shop is regarded by many engineers as an unwelcome necessity. The nature of the work involves hand labour and processes so different from the ordinary principles of manufacture that conditions are tolerated in this trade that would be viewed with grave concern in others. In pre-war days, when the labour in the pattern-shop was more plentiful, it was—except in the case of large engineering firms—generally considered sufficient to instal what might be termed "modern" types of wood-working machinery. To-day, pattern-shop labour scarcity has doubled the trials of the firm whose pattern shop has been undeveloped and neglected.

It is generally known, that in a pattern shop no two jobs are alike, and the principles of manufacture which apply to repetition woodwork are out of the question. A machine to operate on bends and irregular cuts of patterns and core-boxes, where, probably, only a single cut is required, must conform with certain well-defined requirements. Firstly, the machine must be sufficiently flexible to give a combination of simple movements which will readily, economically, and conveniently operate upon geometric and irregular patterns with the infallible accuracy of mechanical control. Secondly, owing to the ever-varying details of pattern work and the fact that in many cases only single cuts are required at one setting, the machine must possess an effective range of simple adjustments, quick action, fine positive feed motions, and highly standardised tools to avoid scheming out and preparing temporary rigs and cutters. Thirdly, the whole equipment must be instantaneously adaptable to work of any nature and bring all movements and operations well within the grasp and manipulation of an average workman.

The machine known as the mechanical wood-worker, manufactured by Messrs. Wadkin and Co., of Leicester, which we illustrate on page 212 and the present page, has been specially developed to fulfil the above requirements. In Fig. 1, on page 212, the machine is shown set up in its vertical position while in Fig. 2, on the same page, the machine is set with the spindle in the horizontal position. The time taken in changing from the vertical to this horizontal position is about 10 seconds. In Fig. 2 the overhanging arm is deflected and the spindle head is in the horizontal position. This overhanging arm floats up and down on sensitive bearings, and gives a range of movement such as will allow it being raised above its horizontal position or depressed until the spindle is below the level of the work table. A taper plunger pin ensures the arm being instantly set to its dead horizontal position and a suitable locking device, within easy reach of the operator, fixes the arm at any desired angle.

The floating of the overhanging arm, whilst the cutter is running, enables irregular moulded work to be operated and gives a range of very useful cuts. Fig. 2 illustrates the machine operating on one of the multifarious forms of core-boxes which can be produced mathematically correct by this machine. The spindle head swivels between the vertical and the horizontal, and can be instantly locked at any angle. The principal angles are mechanically located by a spring plunger-pin and intermediate angles located by index. It will be obvious that the extreme flexibility of the machine will give a wide and adequate range of cutting operations of geometric and irregular shapes.

The cutting spindle runs on two double-row ball bearings contained in dust-proof grease-packed hous-

ings, which method is also applied to a ball-bearing washer for taking the end thrust. The spindle can be rotated in either direction, thus enabling the cutter to work with the grain of the wood, and a reversing lever is so placed that it is unnecessary for the operator to alter his position when reversing the direction of rotation.

Two independent motions are provided for feeding the cutter spindle into the work, one being a quick motion by hand lever while the other is a fine screw adjustment by hand wheel. Both motions can be locked and stopped mechanically where desired. The cutter spindle has three speeds to suit the various sizes and types of cutters used. It is driven by belt over suitably-placed guide pulleys from a shaft at the back of machine, the latter being driven by a countershaft. When required the machine may be driven by a variable-speed motor mounted on a bracket at the back of the machine. By this arrangement the back shaft is replaced by the motor thus making the machine quite self-contained.

Fig. 3, page 221, illustrates a specimen of pattern-making which is a most simple machine operation, but difficult hand work. Wrought by hand, a considerable amount of labour and skill is involved to get an accurate finish, especially with S or swan-neck bends. The cuts are essencially mechanical cuts and the machine operates on such bends of various radii and complicated forms by a simple semi-automatic movement which guarantees accuracy. For this sample the timber is roughly cut on the band saw to the approximate shape, the machine table is then set to the correct radius by traversing the table slide the required distance from the cutter spindle, and the work is shaped up as shown in the illustration; the cutter cleans up both the inside and outside of the pattern.

The main frame of the machine is clearly shown in the figures. It will be noticed that the base is exceptionally large and the frame, being a heavy cored casting in one piece, vibration is eliminated even when the machine is running at the highest speed and taking heavy cuts. The work table is of a heavy pattern, designed to equalise all stresses which may have a tendency to overbalance the table when heavy work is fixed in any position upon it; it is provided at regular intervals with tapped holes for securing the adjustable holding-down cramps. The table has right-angle motions, one operated by machine-cut rack and pinion, the other controlled by screw and hand wheel, the screw nut of the latter motion is split and can be instantaneously opened or closed. This allows the table to be operated by the screw or floated to and fro' by hand. Ball bearings, protected by chips and dust by a special cage, are fitted under the work table to ensure the freedom of rapid movement which is absolutely essential for all classes of work where the table is moved by hand. The table slides are mounted on a pillar, the base frame of which is fitted with anti-friction rollers and travels to and fro' upon a runway. The table can be turned in a complete circle upon this pillar and locked when required; this circular motion is provided with adjustable clips for limiting the angle through which it is desired to move the table. The work table can be raised and lowered by screw gear actuated by handle within easy reach of the operator.

The pattern bend shown in Fig. 3, on page 221, is being dealt with upon an auxiliary table. This auxiliary table turns about a fixed centre pin and can be fixed to the main table in 30 seconds; it can be used for all small work, such as bends and sweeps up to 18 in. radius. The table is operated by a hand lever fitted with a spring plunger taper pin engaging in holes suitably placed in the main table, so that all the principal angles are mechanically obtainable; an adjustable locking bar secures the table at any intermediate angle. The working surface of the auxiliary table is marked out in such a manner that it is not necessary to set out any of the work with the exception of the two right-angle centre lines.

One of the most difficult and expensive hand operations in pattern-making, requiring no small degree of intelligence, skill and training, is gear cutting. This work is by far the most costly and intricate process to be found in the shop and involves considerable time and labour to get even approximately accurate results by hand. An example of the mechanical method of cutting patterns for gears by the machine under notice is shown in Fig. 4, on page 221. The machine is operating on a helical wheel and pinion; this was completed in 8 minutes, which time included setting up the machine. This job represents in hand-work about 40 hours, so that it is needless to further discuss the advantage of machine cutting. Our space in this short article only permits of a description of a fraction of the wide range of wood-working operations this machine and its equipment is capable of undertaking. It is equally useful in motor body-building and air craft construction, joinery and cabinet-making, and when it is not employed upon special work, it will take any ordinary repetition work about the shop.

THE GENERAL PRINCIPLES OF THE DEVELOPMENT AND STORAGE OF WATER FOR ELECTRICAL PURPOSES.*

By J. W. Meares, Member.

Introductory.—The extensive use of hydro-electric development is a noticeable feature of most countries which possess natural water power, especially where there is concurrently an absence of coalfields, but the general principles underlying such developments are very little understood outside the ranks of those directly interested. Great Britain has vast quantities of coal and very little developed water power, with the result that most of her engineers never have occasion to study water power. But many of her sons will inevitably emigrate after the war, and the engineers among them will find themselves handicapped if they are unable to deal with problems of this nature.

There is not a great deal of literature on the subject; papers read before learned societies consist for the most part of descriptions of particular installations, while treatises dealing with this branch of engineering are largely concerned with details of electrical transmission and other cognate matters. It is proposed in this paper to examine the subject purely from the point of view of delivering, and continuing to deliver, water to a prime mover, from which point onwards the problem does not greatly differ from that of the ordinary central station or group of interlinked stations. The last paper read before the Institution on the general subject of water power was that by Mr. A. Steiger in 1896,† and it was concerned mainly with types of low-fall turbines. In the present paper mechanical design is not touched upon; the collection, storage, and delivery of water on high, medium, and low falls is the whole scope of the contribution.

The Conditions Requisite for Water Power; Classification according to Head.—A country may have vast rivers and yet very little water power capable of economic development. For, unless a natural fall is ready to hand, an artificial one must be created. If a river bed has a slope of only a few inches to the mile, as is the case with many large rivers in flat countries, the power that exists in the sluggish flow is incapable of utilisation except possibly by very small undershot waterwheels. The difference of level at different seasons would alone put any such proposals out of court, as would also the cost.

As the power obtainable in any case is proportional to the product of the weight of water multiplied by the height of fall, it follows that either a large volume of water flowing under a small head or a small volume flowing under a high head will serve; the majority of installations actually utilise a medium volume flowing under a moderate head. The problems of low, medium, and high heads differ considerably, however, and each may be dealt with in various ways. There is one exact line of demarcation between the three stages, but, generally speaking, low heads may be taken to be those involving the use of pressure or reaction turbines, often submerged, with suction or draught tubes connecting the outlet with the tail race, from about 3 ft. as a practical limit up to 80 ft. or 100 ft. High heads are such as are dealt with by the jet impulse type of wheel exemplified by the Pelton wheel, from a possible 5,000 ft. or so down to 300 ft. or 400 ft. Between these two extremes lie the medium falls, using impulse turbines of various types according to the head. In America this type of wheel is little used and jet impulse wheels are mostly used. For ready reference the theoretical spouting velocity [$V = \gamma (2 g H)$] and static pressure ($P = 0{\cdot}433$ lb. per square inch per foot of head) are given in tabular form for various heads. The actual issuing velocity will be slightly less, about 3 per cent. to 4 per cent., on account of the frictional resistance of the edges of the orifice; while the pressure at the nozzle will be lower normally by the loss of head in the system, and may be greatly increased by water hammer if the flow is suddenly arrested.

Table I.

Head in Feet.	Spouting Velocity; Feet per Second.	Static Pressure; Lb. per Sq. In.
3	13·9	1·30
10	25·3	4·33
50	56·6	21·6
100	80·0	43·3
500	179·0	216·0
1,000	253·0	433·0
3,000	438·0	1,299·0

The gross head in high and medium falls is the vertical difference in height between the point of application to the wheel and the water-level at the pipe intake; while for low heads the difference between the level of the head and tail waters must be taken. The net head is the gross head diminished by the loss in the connecting system.

Flow and Storage.—The above classification according to head may be further subdivided in considering possible sources of water power, for just as the head may be natural or artificial so may the flow of water. With rivers and canals the natural flow is the prime feature, and even with mountain streams it is of great importance; but in every case, given suitable conditions, storage may be an almost equally important factor. In a project recently described* natural flow into the reservoirs only operates for a few weeks during the monsoon, and for the greater part of the year the maintenance of supply is dependent solely on storage; more frequently flow and storage are combined, and the conditions resulting from each category are dealt with in this paper.

Efficiency of Hydro-Electric Plant.—At the most economical load the efficiency of various types of hydraulic turbine or wheel varies from 85 per cent. to 90 per cent. in large sizes, while the corresponding overall efficiency of alternators, including excitation losses, will be from 95 per cent. to 97 per cent. Thus the overall efficiency under the most favourable conditions will vary from 81 per cent. to 87 per cent. In practical working, however, the most favourable conditions are not maintained; the plant will not all be running at full load and there will be some appreciable additional loss in all systems having any length of pipe—a loss increasing with time and incrustation. In low-head plants eddies also affect the efficiency. For practical industrial purposes it will be sufficient to assume the overall commercial efficiency, E, of the plant M to be as in Table II.

Table II.

	Per Cent.
For 500 kw.	74
For 1,000 kw.	76
For 1,500 kw.	78
For 2,000 kw.	80
For 3,000 kw. and over	82

Using the convenient irrigation unit of a "cusec" for a flow of a cubic foot of water per second (termed a foot-second in America), we then have:

E.H.P. output

$$= \frac{\text{cusecs} \times 62{\cdot}4 \times \text{gross head in feet}}{550} + \frac{E}{100}.$$

As, however, we are more concerned with kilowatts than with electrical horse-power it will be convenient to use a direct conversion factor and to avoid decimals of no real significance, as follows:—

Table III.

For 500 kw.	= cusecs × gross head × 0·062.
For 1,000 kw.	= cusecs × gross head × 0·064.
For 1,500 kw.	= cusecs × gross head × 0·066.
For 2,000 kw.	= cusecs × gross head × 0·068.
For 3,000 kw. or over	= cusecs × gross head × 0·070.

For rough purposes indeed it is quite sufficient to take kilowatts = cusecs × feet/15, or brake horse-power of turbine = cusecs × feet/11 for mechanical power as reliable mean figures, except for small installations where the divisor will be higher.

From these data the curves in Fig. 1 have been drawn, giving the kilowatts which will be generated from any flow under any head within practical limits. Thus

6,500·0 cusecs on 3·5 ft. head will give 1,500 kw.
650·0 cusecs on 35·0 ft. head will give 1,500 kw.
65·0 cusecs on 350·0 ft. head will give 1,500 kw.
6·5 cusecs on 3,500·0 ft. head will give 1,500 kw.

Interpolation will find intermediate heads between the curves near enough for all practical purposes.

Before proceeding further it is necessary to point out that even in the most favourable circumstances the water flowing through the turbines is only a proportion—and a very variable proportion—of that which is precipitated on the catchment area. It is therefore necessary to refer generally to the factors of rainfall, run-off, evaporation, percolation, and other matters which affect the problem, especially where storage is an essential part of a project.

The author is at present engaged upon the survey of the water-power possibilities of India and Burma, which has been placed under the direction of Mr. G. T. Barlow, C.I.E., late chief engineer for irrigation in the United Provinces; and as the East Indies are for the most part subject only to seasonal monsoon rainfall, the conditions there are somewhat special with regard to these disturbing factors, although much that follows will be common to all countries.

Rainfall and Run-off.—If the rainfall over a particular catchment area in any period is actually known, and the stream flowing from it can be gauged, the percentage of run-off can at once be calculated for the conditions obtaining during that period; but the rain-gauge readings must be taken at a number of points—the more the better—in the catchment in order to ascertain the actual amount of precipitation. In addition to the very large differences of average rainfall in different countries and localities, and the great variations from the average in particular years, the distribution of the fall, month by month and day by day, must be taken into account. Unless enormous reservoirs can be constructed, the greater part of the rainfall in a monsoon area must inevitably flow to the sea unused either for power or for irrigation.

To take an example, the "Preliminary Report of the Water Power Committee of the Conjoint Board of Scientific Societies" states that "The catchment area drained by the upper reaches of the rivers (i.e., the Irrawaddy and Salween) is about 80,000 sq. miles, and assuming it possible to utilise one-fifth of the discharge (based on 100 in. of rainfall) over a head of 500 ft., this would give a potential 7,000,000 h.p. Actually much the greater part of the discharge is in the monsoon months and by no possibility capable of utilisation, and it is doubtful if a head of even 100 ft. could be developed at any places within reach of civilisation. Too much water is almost as great a disadvantage as too little, owing to the extreme difficulty of getting

* Paper presented to the Institution of Electrical Engineers.

† A. Steiger, "The Utilisation of Water Power, especially with a Small Fall," Journal I.E.E., 1896, vol. xxv, page 521.

* A. Dickinson, "The Bombay Hydro-Electric Scheme," Journal I.E.E., 1915, vol. liii, page 693.

rid of it. These rivers could, no doubt, be harnessed, at enormous cost, for perhaps 500,000 h.p. if there were not many far more favourable sites among their tributaries.

Minimum discharges on small catchments may vary four or five-fold in different years, and are extremely difficult to calculate; a long series of rainfall averages will, however, indicate to some extent the relation between the unknown discharge of an exceptionally dry year and the known discharge of a particular year. Intelligent guesswork of this nature presupposes knowledge of local conditions and long experience.

Formulæ for calculating the maximum run-off from a catchment have been devised by many engineers,* but they all employ coefficients which it is impossible to ascertain without a comprehensive study of the nature of the area and the rainfall. It may, however, be accepted that a study of the daily rainfall observations over a period of thirty years will give a fairly accurate idea of the conditions which are likely to occur in future, and if different percentages of run-off are assumed for light, medium and heavy falls, depending on the nature of the catchment, a fairly accurate forecast can be made.

As a practical example of the method, the following empirical table has been tentatively adopted in the United Provinces (India). The author's acknowledgements are due to Mr. G. T. Barlow, C.I.E., chief engineer, for permission to publish it, as well as for much of the information in this section of the paper.

Light falls under ½ in. in 24 hours should be entirely omitted unless continuous for several days; falls from ½ in. to 1 in. in 24 hours should be omitted if there has been no fall before or after. Falls from 1 in. to 1½ in., when not followed or preceded by similar or greater amounts, are considered to be light.

Medium falls are those from 1 in. to 1½ in. when followed or preceded by any light falls; also all falls from 1½ in. to 3 in.

Heavy falls are those over 3 in., or continuous falls over 2 in. a day; also all falls of an intensity of 2 in. an hour or over.

TABLE IV.—*Showing Percentage Run-off Assumed.*

	A.	B.	C.	D.	E.
	per c.	per c.	per c.	per c.	per c.
Light falls	1	3	5	10	15
Medium falls	10	15	20	25	33
Heavy falls	20	33	40	55	70

A = flat, cultivated and black cotton soil catchment.
B = flat, partly cultivated and stiff soils.
C = average catchment.
D = hills and plains with little cultivation.
E = very hilly, steep and rocky with very little cultivation.

Obviously such a classification would be unsuitable in most parts of Europe or America, but it brings out clearly the nature of the variations to be met with in a particular locality. A thunderstorm with a rainfall of ½ in. in 20 minutes would give double or treble the run-off of the same fall spread over a day; but nearly all rainfall observations give the daily fall and not the hourly intensity. The classification of daily rainfall over a long period sounds a serious proposition, but is really a matter of clerical labour only. Owing to the disturbing effect of hills, &c., isolated observations at one point of a catchment may be very misleading; hence the necessity of many gauging stations wherever possible. Rainfall contour maps are only useful as a general guide, unless prepared on a large scale from observations made for the purpose.

In India the rainfall varies in different localities from 450 in. to a few inches, mostly precipitated in about four months, while catchment areas vary in nature from waste sand to steep rocky country. In some parts the ground is highly cultivated or covered with dense forest, while in others there is hardly any soil or vegetation; the soil itself varies from the stiffest clay to the lightest loam or sand. With these variables it is easy to realise that the run-off must vary greatly and is incapable of treatment by any general formula of universal applicability.

Evaporation and Percolation.—Apart from the fact that a considerable percentage of rainfall is evaporated before it reaches the big rivers, as well as from their surface, the question of evaporation arises wherever long canals or large storage reservoirs are employed. The actual amount of evaporation varies so greatly that no general figure would be of the slightest value; in India it may be as much as 6 ft. in the year, but for details of many known reservoirs Buckley's "Irrigation Pocket Book" may be referred to. Percolation and absorption also account for no small amount of the water entering a canal in natural ground or a reservoir, but the loss must obviously be determined in each case as it arises. Owing, therefore, to these various unknown factors, the data given in relation to storage in this paper, except where otherwise mentioned, do not take into account the losses due to them.

The following figures are worth remembering in connection with water-power projects involving storage.

Thirty-one and a half million cubic feet of water will give 1 cusec throughout a year; or, taking losses into consideration, about 35,000,000 cub. ft.

A square mile submerged to 1 ft. gives about 27,750,000 cub. ft., and an acre-foot about 43,000 cub. ft. The use of billions (as in the United States of America and Canada) is open to objection as it has at least two different meanings. The original term in astronomy connotes a million millions, and is still current, whereas it here stands for thousands of millions only.

Reservoirs.—While in most countries the rivers and streams are perennial, this is not generally the case in India where many imposing streams dry up entirely before the monsoon; furthermore, practically the whole hot-weather discharge is taken up for irrigation in many other instances, although it fortunately happens that the headworks of the irrigation canals are generally taken off at a point below that which would be most suitable for power purposes. Where storage can be developed on a large scale it may go far towards balancing the deficiency of flow in the dry season, whether for irrigation or for power or for both.

The best sites for the dam containing the reservoir and for the escape for surplussing the excess flood waters require careful consideration. The ideal site for a reservoir is where a stream with a good catchment area runs through a fan-shaped valley with flat longitudinal and transverse sections. The soil, cultivation, habitations, and other works must also be considered with regard to both the location and the economic height to which it is advisable to store water. The dam should evidently be placed where the valley contracts and, if possible, where there is good solid rock to found upon. Trial pits alone are not sufficient evidence, and the whole alignment should be trenched.

Where the catchment is large, the valley cultivated, and the flood water escaped over the dam itself, it is generally more economical to build the dam where the best rock for the foundations is found, rather than at the narrowest point of the valley.

Excess flood water can be escaped either over the top of a masonry dam, or by undersluicing, or by a separate flank or saddle escape. In all cases it is necessary to have solid rock or masonry, as otherwise the high cost of the protective works is likely to ruin the project. Flank or saddle escapes are generally used when the main dam, whether of masonry or of earth, is founded on soft rock or earth. Occasionally, when the catchment area is small, and rock foundations cannot be obtained, it is advisable to construct the dam to such a height that the whole of the run-off may be stored.

The economic height of the dam and the line to which storage water is to be collected depend upon:—

(*a*) The requirements for power or irrigation, or both.

(*b*) The catchment area available for storage; it is frequently possible either to add extra catchment areas at a small cost, where water is deficient, or to divert a portion of the area to another drainage when it is in excess of the requirements and there are difficulties about the escape.

(*c*) The rainfall on and the actual run-off from the catchment.

(*d*) The nature of the submerged area, where an extra foot or two of height may involve on the one hand the submergence of valuable property or, on the other hand, may mean an extra 50 per cent. to 100 per cent. of storage capacity.

(*e*) The nature of the seasons; for in some places the annual rainfall is very variable in both amount and intensity, so that the run-off may vary from zero to nearly 100 per cent. of the rainfall. In such cases provision must be made for the carrying over of the water from the good to the bad years. This is especially necessary in all reservoirs used for power or sanitary purposes, and may not always be possible in irrigation projects.

Water Storage and Power.—Whether water is stored on a large scale behind dams, or on a small scale in reservoirs, there are many variable factors in addition to the efficiency of the plant; the original capacity is seldom known with exactness and varies according to the amount of silt deposited, or the date of the last cleaning-out in the case of reservoirs capable of such treatment. It will be sufficient, therefore, to assume here an overall efficiency in the plant of 76 per cent., giving straight-line "curves." With this efficiency 1,000 kw. requires a flow of 15·54 cusecs under 1,000 ft. head, or 15,540 cusec-ft. under any other head.

With the assumed head of 1,000 ft. this flow of 15½ cusecs represents (in round figures and exclusive of evaporation and percolation) 1½ million cubic feet a day; 41,000,000 cub. ft. a month; 490,000,000 cub. ft. a year; to maintain 1,000 kw. continuously in each case. For any other head the storage will vary in inverse proportion, while for any other value in kilowatts of continuous output it will vary in direct proportion.

Now 1 kw. for a year represents 8,760 B.O.T. units, so the above 1,000 kw.-years give 8,750,000 units on the assumption of 100 per cent. load factor. The amount of storage is therefore directly proportional to the units generated, whatever the load factor may be; for if the load factor is 50 per cent. it follows that 2,000 kw. of plant can actually be maintained by the above quantities on the assumed head, while the output in units will be unaltered. The logarithmic diagram (Fig. 2, on page 224), illustrates the relation of storage to B.O.T. units for any head. Thus for 2,000 ft. head the 200 ft. curve may be used and either the units multiplied by 10 or the storage divided by 10; and so forth. As before, interpolation (for which any slide rule will serve if laid so that 1 and 10 correspond on the diagonals) will give intermediate heads; and if the cubic feet be multiplied or divided by 10, 100, &c., the ordinates (units) similarly treated will correspond. A scale of kilowatt-years on 100 per cent. load factor can be laid off by taking 1 kw.-year at 8,760 units, 10-kw.-years at 87,600 units, and so forth.

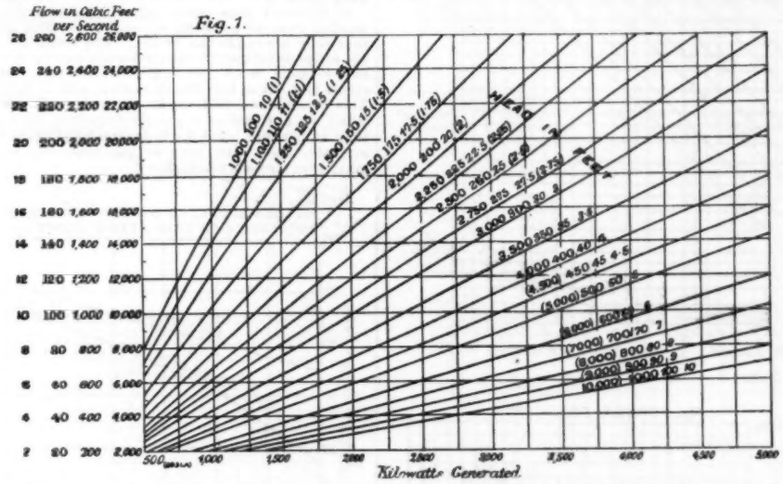


FIG. 1.—Number of kilowatts obtainable from any flow of water under any head from 3 feet upwards. The figures of flow correspond from left to right with those of head, as shown by the different type employed.

By way of illustration, Mr. Dickinson's paper already quoted gives the details of three lakes on the Bombay (Tata) hydro-electric scheme, containing respectively 361,000,000 cub. ft., 2,560,000,000 cub. ft. and 6,963,000,000 cub. ft. of water. These reservoirs are at considerable distances from the fore-bay supplying the pipes, and the static head is 1,725 ft. From the diagram it will be seen that as 31·5 million cubic feet give 100,000 units on 175 ft. head, or 1,000,000 on 1,750 ft. head, the three lakes will give about 11,500,000, 80,000,000 and 220,000,000 units respectively, subject to correction for evaporation and losses. On the basis of 100 per cent. load factor they would supply about 1,300 kw-years, 9,000 kw.-years and 25,000 kw.-years respectively. The actual load factor of the plant on the last returns available was 30 per cent., so the plant capable of being served under working conditions is about three times the above; and, in fact, the full reserve would allow a considerable defect in the monsoon rainfall without endangering continuity. The largest reservoir is not yet completed.

The height of the water in the lakes affords therefore an immediate gauge of the reserve in hand. In the chief engineer's office is a curve showing the actual reserve for every foot of water behind the dams. Thus the surface area of the Shirawta Lake when full is 3,174 acres, so that the first foot of depth is equivalent to 138,000,000 cub. ft. of water, or 4,500,000 units.

Limitations of Storage according to Head.—The function of water storage is two-fold; on the one hand, increase of power throughout the year or the dry season; on the other hand, regulation day by day. The latter may in favourable conditions also enable the size of the plant to be substantially increased. The incidence of the rainfall, the rate of evaporation, the natural possibilities of the ground, and the load factor of the plant all enter the argument. It is evident that where low heads are involved storage on the above scale of power will be impracticable. The amount of storage that will serve to give, say, 1,000 kw. for a year on 1,800 ft. head would give the same for a month on 150 ft. and for a day only on 5 ft. When a high rate of charge is proposed for the use of water power it is perhaps not realised that it is gravity, not water, which is to be utilised; and that it is because

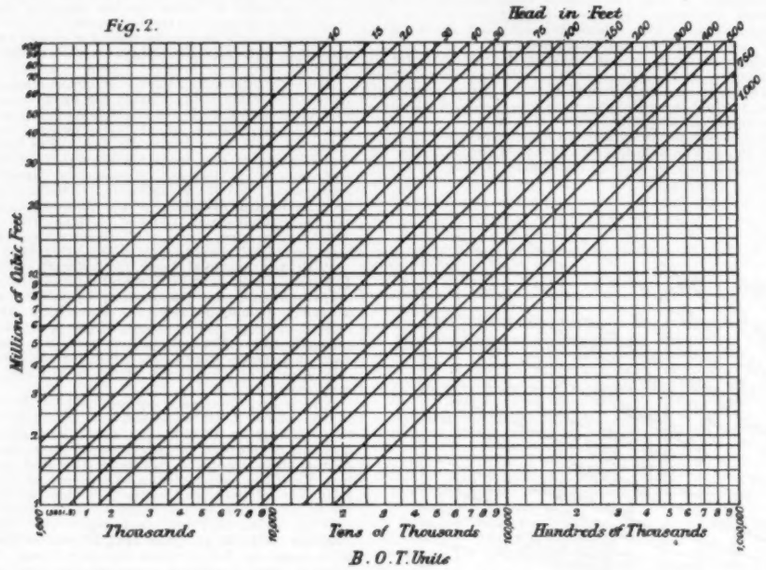
* R. B. Buckley, C.S.I., "Irrigation Pocket Book," second edition, page 192.

water is heavy, not because it is wet, that it is valuable in transit through turbines.

Storage on High Heads.—Within ordinary limits of capital cost, therefore, a project depending entirely on monsoon storage, with no appreciable inflow during the greater part of the year, is impracticable except on high heads. Of course the possibility of storage on the grand scale at all postulates suitable conformation and geological formation of the ground to enable a dam free from serious seepage to be constructed at reasonable cost, and this must be borne in mind in all that follows.

Where a moderate flow of water is normally available under a high head, storage on a large scale may be used to supplement the flow at seasons of low water, provided that the excess flow in flood times can be depended upon to fill the reservoir. Thus a flow of 15 cusecs under 2,000 ft. head will give 2,000 kw. continuously, or considerably more on ordinary load factors. If this flow is the minimum, it follows that much water will be running to waste at other times, in the absence of storage. Assume the average flow throughout the year to be 45 cusecs, then the excess of the area of the curve to its enclosing rectangle) is 34 per cent., so that 14,700 units are generated altogether. The dotted line shows the power which the flow can generate, while the shaded areas represent the period when excess water is being stored and drawn on respectively. Between midnight and 17 hours 5,700 units are actually generated, while the flow is capable of giving 630 × 17, or 10,700 units. Therefore 5,000/10,700 of 20 cusecs or 9·35 cusecs can be stored. This in 17 hours amounts to some 570,000 cub. ft., an amount which will more than serve to supply the extra 4,600 units between 17 hours and midnight. Many a small proposition has been turned down for lack of understanding this valuable application of storage. The advantage of squared paper in dealing with these questions will be evident from the load curve, where $\frac{1}{10}$ in. square represents 100 units and also 11,400 cub. ft. of water. From Fig. 2 it will be seen that this is so, as 10,000 units on this head correspond to 1,125,000 cub. ft. The slight disproportion is due to the efficiency of this small plant being taken at 74 per cent., whereas the storage curves take 76 per cent.

Fig. 2.

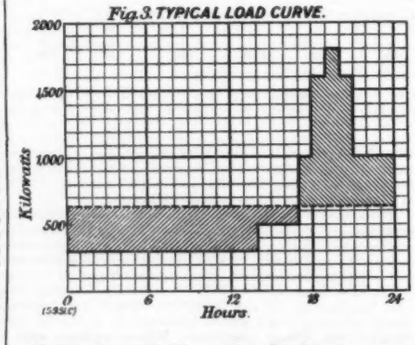


30 cusecs can be stored. It would amount to 950,000,000 cub. ft. in the year, but, as there would be a draw-off whenever the flow diminished, only a proportion of this storage capacity would be actually required. It would suffice to give a further 4,000 kw. continuously, so the whole plant, assuming a 50 per cent. load factor, could be 12,000 kw.

Storage on Medium Heads.—In the same way where a moderate minimum flow is combined with a medium head, storage on the same large scale can be utilised to impound the excess flow within limits. If the minimum flow is equivalent to 2,000 kw., say, 100 cusecs on 300 ft. head, and the average flow is 200 cusecs, it is clear that the whole of this excess could not be stored without undue expense; but a reservoir of practicable size would enable a larger plant than 2,000 kw. to be installed. If the whole of the excess rainfall were precipitated in the course of a few months the greater part of it would necessarily pass over the spillway and the amount retained would only suffice to keep a moderate sized unit working for the remainder of the year; but if the rainfall were well distributed much more of it could be utilised. Fig. 2 will enable these two conditions to be investigated for any size of reservoir. Where rainfall is fairly regular, except for a few dry months, storage would act as a reserve to tide over the dry period with a larger plant than the minimum flow could deal with. Assume 1,000,000,000 cub. ft. of storage. Then, on 300 ft. head, this is equivalent to 5,500,000 kw.-hours. In the first instance this would mean an extra 800 kw. working continuously for nine months; in the third case it would keep 2,400 kw. at work for the three dry months; subject in both cases to the load factor, which would allow more plant actually to be installed.

It generally comes about that on medium heads storage can only be utilised as reserve against drought, or against breakdown in the water channel where one is necessary, and not for increasing the plant capacity greatly above that maintained by the normal flow. For regulating purposes, however, it can be exceedingly useful, especially where the load factor is bad. Thus, in the case of a small plant, if the daily maximum load over the lighting peak is three or four times the average load, and the normal minimum flow can be depended upon at the forebay, i.e., excluding the liability to serious breakdown in the flume or channel—very little storage will be of great value. Assume a minimum dry-season flow of 20 cusecs and a head of 500 ft., equivalent to 630 kw. generated. This minimum flow is then capable of generating 15,000 units per diem, if it can all be utilised. The load curve, Fig. 3, squared for convenience of demonstration, shows a peak load of 1,800 kw. for an hour, and the load factor (i.e., ratio

Fig. 3. TYPICAL LOAD CURVE.



Storage Impracticable on Low Heads.—As a general rule large-scale storage is impracticable on low-head plants; that is to say, although there may be a considerable reserve behind a dam, either feeding directly into the turbines or further up-stream, it is generally no more than suffices for regulation. The enormous volume of water required to maintain a large unit of plant for even a month would render such a proposition commercially impossible.* In rare cases only would the lie of a river allow impounding on the necessary scale, while with a canal it would never do so. As a rule, however, the flow in low-fall installations is fairly regular, so that no storage is required.

(To be continued.)

Institution of Naval Architects.—The limit of time for accepting entries for the Cammell Laird scholarship in naval architecture and the Parsons scholarship in marine engineering has been extended to August 31. Application forms may be obtained from the Secretary, Institution of Naval Architects, 5, Adelphi Terrace, Strand, W.C. 2.

* About 16,000,000,000 cub. ft. of water would be required to maintain only 100 kw. for a year on a 3-ft. head. This is over twice the quantity the Shirwata dam is designed to hold up. Journal I.E.E., 1915, vol. liii, page 693.

METAL CONSTRUCTION OF AIRCRAFT.*

By A. P. Thurston, D.Sc., F.R.Aë.S., F.R.Met.S., M.I.A.E.

(*Concluded from page* 180.)

APPENDIX I.

Thin strip steel of various qualities, having thicknesses ranging from 0·014 in. to 0·028 in. have been experimented with by Messrs. Arthur Lee and Sons, Limited, Sheffield, for the construction of aeroplanes. This has entailed investigations upon a matter of 135 different samples, including the following:—

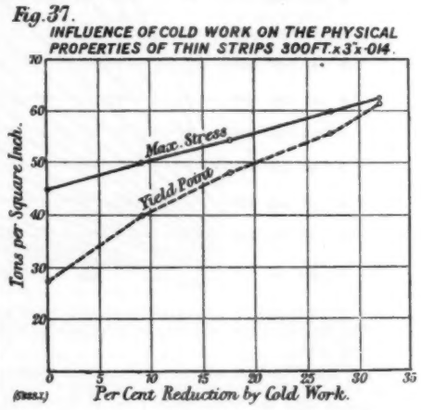
1. The influence of cold work upon the physical properties of thin strip;
2. The influence of "tempering" cold-worked thin strips; and
3. The influence of "tempering" hardened thin strips upon the physical properties.

The attached graphs show the various influences. It was found that alloy steels were of no material benefit over plain carbon steels in the "as cold-worked condition"; the alloy steels requiring to be heat-treated in order to bring out their good physical properties and be of any advancement over plain carbon steels. Thin strips have been obtained and manufactured by us having yield points from 35 tons to 100 tons per square inch. Not only in carrying out these experiments has this been attained, but we have supplied on a commercial scale the Aeronautical Supplies Department, and others, with several tons of thin steel strips, to the 60-ton yield specification, in lengths of 300 to 400 ft. each.

The following is a short *résumé* of experimental work done by us:—

It is found that where strips receive a greater reduction than 40 per cent. by cold work after annealing that they are made too brittle. The breaking stress of the strips is related to the cold work put upon them by the formula $S = 30 + \frac{1}{2}R$, where S = maximum stress and $\frac{1}{2}R$ = half the reduction, and so is constant. This formula we find works out very well with strips which do not receive a greater reduction by cold work than 40 per cent., and the following table bears this out, and also that with over 40 per cent. the calculated maximum stress is too high.

Fig. 37.



Sample No.	Actual Breaking Stress.	Calculated Breaking Stress from $S = 30 + \frac{1}{2}R$.
	tons per sq. in.	
0	33·9	$30 + \frac{0}{2} = 30·0$
1	45·5	$30 + \frac{31\frac{1}{2}}{2} = 45·65$
2	50·0	$30 + \frac{49\frac{1}{2}}{2} = 54·62$
3	51·8	$30 + \frac{60·35}{2} = 61·17$
**	30·0	$30 + \frac{0}{2} = 30·0$
4	43·2	$30 + \frac{25}{2} = 42·5$
5	47·0	$30 + \frac{41·75}{2} = 50·87$
**	30·0	$30 + \frac{0}{2} = 30·0$

The annexed Tables A and B, and the diagram Fig. 37, show the influence of cold work on the physical properties:—

Some of these results are given graphically in the diagram, Fig. 38. It will be seen that the tempering or "blueing" from 0 deg. C. to 400 deg. C. has increased the yield point and maximum stress over the cold-worked value. There appears to be a critical point between 400 deg. C. and 500 deg. C., where the fall in yield and maximum stress occurs, whilst the elongation is greatly increased. The maximum stress and yield point do not lower again to that of the original cold-worked figures until about 425 deg. C. is reached. This pheno-

* Paper read before the Royal Aëronautical Society, on May 14, 1919.

menon is remarkable, but there is no doubt about it, as this has been proved by us many times, it being experienced on tempering all cold-worked materials. The bend tests are not improved by this tempering until over 425 deg. C. is reached.

TABLE A.—INFLUENCE OF COLD WORK ON THE PHYSICAL PROPERTIES OF THIN STRIPS. LENGTH OF STRIP 300 FT.

Size.	Condition of Strip.	Yield-Point.	Maximum Stress.	Elongation Percentage on 2 in.	Scleroscope Test. Hardness.	Erichsen Value.	Bend Test over Radius of Three Times the Thickness.	Percentage Reduction by Cold Work.
		tons per sq. in.	tons per sq. in.		deg.			per cent.
3—½" × 0·022	Before cold work..	27·2	45·6	11·0	22	7·00	Good	None
3—½" × 0·020	After cold work ..	40·0	50·0	10·0	32	6·80	Good	9·09
3—½" × 0·018	After cold work ..	47·6	54·25	3·0	38	6·35	Good	18·18
3—½" × 0·016	After cold work ..	55·2	59·8	2·5	42	4·90	Good	27·27
3—½" × 0·014	After cold work ..	61·2	62·2	2·5	38	5·00	Good	31·81

TABLE B.—THE INFLUENCE OF TEMPERING ON THE PHYSICAL PROPERTIES OF COLD WORKED STRIPS 0·028 IN. THICK.

Condition of Strip.	Yield-Point.	Maximum Stress.	Elongation Percentage on 2 in.	Erichsen Value.	Bend Test over Rod 0·140 in. Dia.
	tons per sq. in.	tons per sq. in.			
As cold worked	40·75	40·75	4·0	5·6	Broken.
After tempering at 200 deg. C.	47·25	47·6	2·5	5·36	Broken.
After tempering at 300 deg. C.	46·5	48·2	4·0	4·23	Broken.
After tempering at 400 deg. C.	44·6	45·6	6·0	4·72	Good.
After tempering at 500 deg. C.	31·0	36·5	17·0	5·12	Good.
After tempering at 600 deg. C.	25·0	31·7	29·5	6·0	Good.

TABLE C.

Hardened Strips Tempered at	Yield-Point.	Maximum Stress.	Elongation Percentage on 2 in.	Erichsen Value.	Bend Test over 0·140 in. Dia. Rod.
	tons per sq. in.	tons per sq. in.			
200 deg. C.	101·0	114·0	2·5	1·28	Broken.
300 deg. C.	81·8	92·3	3·5	2·80	Broken.
400 deg. C.	66·8	80·7	6·0	4·60	Broken.
500 deg. C.	61·4	70·2	9·5	4·62	Good.
600 deg. C.	43·4	48·0	11·0	3·70	Good.

Fig. 38.

THE INFLUENCE OF TEMPERING ON THE PHYSICAL PROPERTIES OF COLD WORKED THIN STRIPS ·028" THICK.

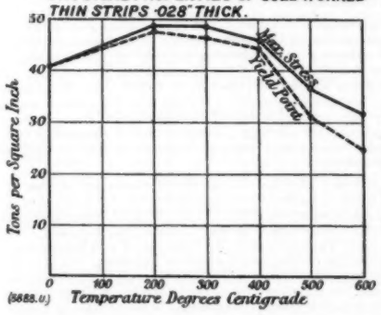


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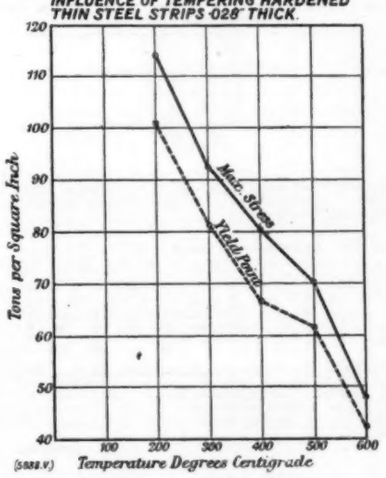
Fig. 39.

INFLUENCE OF TEMPERING HARDENED THIN STEEL STRIPS ·028" THICK.



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It may be of interest to mention, at this stage, that on making tensile tests on thin strip steels, after the yield point has been reached they break in a peculiar manner, diagonally, with V top and bottom, and sometimes assume an X, then at the finish break horizontally.

By tempering hardened thin steel strips we get an opposite effect to that which is obtained on tempering cold-worked strips. On tempering hardened strips from 0 deg. to 600 deg. the maximum stress and yield point are decreased, whilst the elongation is gradually increased. The bend tests are improved from 400 deg. to 600 deg. C. All bend tests have been made with metal that is lengthwise of the strip. The annexed Table C and the diagram, Fig. 39, show the results obtained :—

APPENDIX II.

The problem before the steel maker may be briefly stated to fall under the following four heads :—

1. The steel must be one which will give the highest possible tests, especially in regard to the true elastic limit, combined with considerable ductility.

2. It must be capable of being worked into the complex shapes required without showing any signs of cracking.

3. The heat treatment must be of as simple a nature as possible, the temperature range being a fairly wide one.

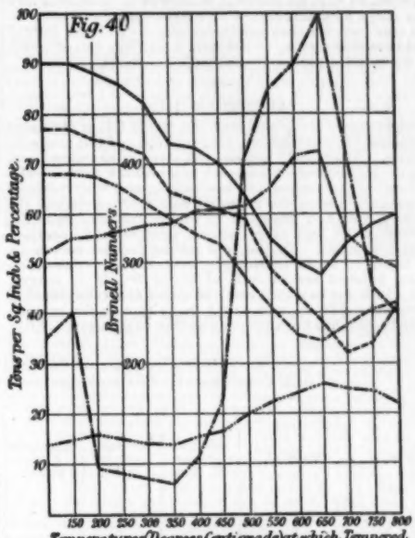
4. The material must be regular, so that the minimum tests may always be obtained by standard heat treatment.

It will readily be seen that in the nature of the proposition, a steel must be used which will give the maximum strength for a given weight. If merely the tensile strength had to be considered there would be no difficulty in producing the necessary material, but, taken in conjunction with the other requirements, the problem does not admit of so ready a solution. Great ductility is also required, as the heat-treated sheet, or strip, which is used in the formation of the spars, has to be formed into the necessary section when in the heat-treated condition, and this is necessarily done by cold forming the section in suitably shaped rolls or dies. Some of the bends are very severe, requiring the strip to fold back upon itself, and as the strip must take this without any signs of cracking, it is obvious that great ductility must be an essential feature of the steel used. This property is also of great importance in those spars where a large amount of riveting is necessary, and as the rivet holes are punched out cold from the heat-treated strip, they must stand this operation without any splitting. In addition to this the steel must be capable of resisting shock as well as withstanding loads more or less gradually applied.

The tremendous strides made in the building-up of spars by welding various members together has made a further and important demand on the qualities of the steels used, and as this method of spar formation seems likely to be of great use, only those steels which weld perfectly will be of any service. The physical qualities of two steels which have proved highly satisfactory when great strength is required, together with all the other desirable qualities, are given in the diagrams, Figs. 40 and 41.

It is very often found that good steel is of little commercial value, because the range of temperature for heat treatment is much too narrow, or else the operations are too complicated, especially when dealing with it in the form of thin strip. These limitations are of the greatest importance when the parts into which the material goes do not admit of being easily tested, or when the working up of the parts accentuates any of the errors in the heat treatment. The steels in question require a heat treatment which admits of a fair range of temperature in hardening, whilst the effect of tempering heats can be readily seen by reference to the diagrams. It will be conceded that regularity is of vital importance, as, unless minimum tests can be relied on, all manner of difficulties will arise, not only in the actual strength of a part, but in the manipulation of the material when formed into shape. These difficulties have all been overcome in the steels in question. There is nothing

Fig. 40.



K.E. 169 STEEL.

Approximate Analysis		Elastic Limit Tons per Sq. In.	
Carbon	·15–·20%	Max. Stress	
Chrome	1–1·25%	Elongation %	
Nickel	3–3½%	Red. Area %	
Sulp. } Phos. }	·03% Max.	Brinell	
		Izod Ft. Lbs.	

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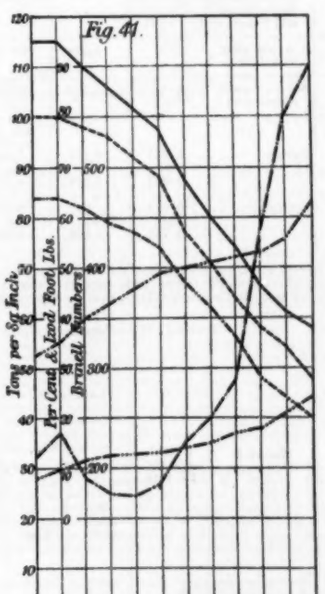
Fig. 41.


Tons per Sq. Inch.
Per Cent. & Izod Foot Lbs.
Brinell Numbers
Temperatures (Degrees Centigrade) at which Tempered for 30 Minutes.

K.E. 897 STEEL.

Approx. Analysis		Elastic Limit Tons per Sq. In.	
Carbon	·25–·30%	Max. Stress	
Chrome	1–1·25%	Elongation %	
Nickel	4–4½%	Red. Area %	
Sulp. } Phos. }	·03% Max.	Brinell	
		Izod Ft. Lbs.	

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now claimed in their composition, but the processes involved from the raw material to the finished strip have been carefully developed, so that every precaution is taken to eliminate sources of trouble. Tests are carried out after every process from the production of the ingot forward, so that no material is allowed to pass from any one stage of manufacture to another unless it is up to the standard for that particular stage. It is the careful and ceaseless testing of the steel which has had so much to do with its success in steel spar construction.

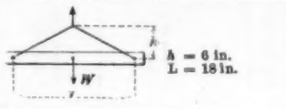
APPENDIX III.

Ingots after being analysed and tested follow the usual processes of manufacture, viz., forging, and hot and cold rolling. After each process the steel is examined and numerous tests are made, and analyses are taken. The re-heating for forging and hot rolling, and the frequent annealings during the repeated cold rollings, require the utmost care and precision to ensure freedom from decarbonisation and other defects produced by incorrect heat treatment. In the cold rolling process care must be taken to avoid crushing by over rolling. The strips when finished are in coils of about 300 ft. in length, the width up to 5 in., and thickness generally running between 0·028 in. and 0·011 in., although for making models strip has been supplied as thin as 0·004 in. After cold rolling the strips are hardened and tempered by special process, in which the temperatures of furnaces and quenching baths are carefully governed by pyrometers, the scale formed in hardening being afterwards removed by a special scouring process. The strip is then finally gauged, and tested for tensile strength and bending capacity longitudinally and transversely. The following tests, with specimens showing examples of bending, illustrate the physical properties of the strip, which is ready for forming into any required section, and is capable of being riveted or welded without further treatment whatever. The steels which have hitherto been used for this purpose are K.E. 169 and K.E. 897.

No.	Size.	Maximum Tensile Stress.	Sclerescope Hardness.	Quality.
	in. in.			
1	4½ × 0·015	43·5	32	K.E. 169.
2	3½ × 0·022	52·2	40	K.E. 169.
3	2·88 × 0·004	53·5	51	K.E. 169.
4	4 × 0·018	71·6	59	K.E. 169.
5	4 × 0·015	75·2	61	K.E. 169.
6	3½ × 0·018	101·3	65	K.E. 897.
7	1·68 × 0·015	103·6	75	K.E. 897.

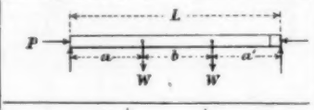
APPENDIX IV.

TABLE I.—Combined Bending and End Compression Tests with Shackle Gear.

Maker.	Material.	Weight, Lb. per Ft. Run.	Central Load, W. in Lb.	Maximum Fibre Stress.	Direct Tensile Stress, Tons per Sq. In.		
					Yield.	Ultimate.	
Vickers Lea design, Ex. D. 3	Duralumin ..	0·421	1,008	tons per sq. in. 19·77	17·95	26·95	Tested to required stress only.
Ditto ..	Duralumin ..	0·421	1,232	24·14	17·95	26·95	Tested to destruction.
Rudge ..	Flanges of K.E. 160 steel. Webs carbon steel file hardened and tempered	0·52	1,270	74·00	—	—	Failure started in flange part of web. This spar is slightly stronger and weighs slightly less than the Grade A spruce spar.
Humber ..	2·5 per cent. nickel steel	0·8	1,028	21·75	30·00	38·1	
Humber ..	5 per cent. nickel steel	0·8	1,252	26·56	46·00	50·1	Failure by buckling of free lips on compression side.
A. V. Roe (front spar)	Spruce ..	0·514 to 0·654	1,232 to 1,568	Lb. per sq. in. 5,950 to 8,016	—	—	All failed on compression side.
A. V. Roe (rear spar)	Spruce ..	0·574 to 0·752	952 to 1,568	6,175 to 9,603	—	—	All failed on compression side.

The results given for wooden spars relate to specimens of good quality tested under best conditions as to dryness. For comparison with metal, the lowest loads supported should be taken and the average weight. The variation of the strength and weight of wood is, however, so large that the figures obtained will unduly favour wood.

TABLE II.—Combined Bending and End Compression Tests.

Maker.	Material.	Weight, Lb. per Ft. Run.	Load in Lb.		Maximum Fibre Stress due to Bending Moment, and End Load, Tons per Sq. In.	Deflection at Centre, In In.	Direct Tensile Stress on Material, Tons per Sq. In.			Remarks.
			W. Transverse.	P. End.			Yield.	Ultimate.		
Rudge ..	Steel. K.E. 897	0·57	350	6,200	69	1·16	50	75–90	a = 10″ b = 30″ L = 50″	Failed by buckling top flange. Guided sideways.
A. V. Roe (rear spar)	Spruce ..	0·574 to 0·752 on 7 good specimens	120	4,770	—	1·13	—	—	a = 20″ L = 60″	Failed in compression 2 ft. from one end.
Simple Bending and Shear Test.										
Dunlop double spar	Steel K.E. 169. Cycle rims clamped together at 5 in. centres.	—	425	0	54	—	48·5	54	a = 10″ a' = 9½″ L = 29½″	Failed by booms bowing out sideways.

It will be noted that both the Dunlop and Rudge spars develop the full strength of the material, since the maximum fibre stress is greater than the yield-point of the material. The Dunlop spar was made by joining two straight pieces of Westwood rim together. The tests prove that the principle of construction is sound. The spar can be cheaply made at the rate of 9 ft. per minute by existing machinery.

"Bulletin Technique du Bureau Veritas." We are glad to welcome the appearance, since June last, of this new publication, which is being issued monthly, in French, by the Bureau Veritas, 31, Rue d'Offémont, Paris. The cost of the annual subscription is 30 francs. The issue we have seen contain articles by Mr. Ch. Doyère on resistance tests of hulls, together with reviews of the British and foreign press. The editor is Mr. J. Delimal, of the French Navy, who before the war was the representative in London of the Paris journal *Le Temps*.

CATALOGUES.

Dowell Pins.—These are made of brass with wood screw surfaces. The socket may be screwed flush into one piece and the pin into the mating piece with the smooth head projecting. The list, which comes from Aeresco, Limited, Birmingham, gives sizes and prices. Stamped brass letters and numbers are also shown.

Light Railways.—A pamphlet in general praise of light railways, from Light Railways, Limited, 3, London Wall Buildings, W.C., exhorts attention to developing the home, and still more the export trade, in this plant. The company supply light railway outfits complete in every detail.

Shaft Couplings.—The British Thomson Houston Company, Limited, Rugby, have issued a catalogue of shaft couplings in three forms, flexible, solid and muff. These are accurately made to standards, and supplied in a wide range of sizes, all for shafts of from ½ in. upwards. The flexible maximum is 5½ in., solid 13 in., and muff 4 in.

Electric Cable Hooks.—A series of standard parts which may be linked together to form a dependent chain of hooks is shown in a catalogue from Messrs. Siemens Brothers and Co., Limited, Woolwich. One or more bolts secure the chain to a wall, and hooks may be used to the number required. Additions are made, when required, by inserting extra standard parts.

Ash Conveyor.—A steam suction ash conveyor is the subject of a special catalogue issued by Messrs. Ed. Bennis and Co., Limited, Bolton. All the parts are shown separately, and example illustrations are given of the whole in fitted-up position. The bends and various connecting and branching pieces, which are subject to severe abrasion, have renewable liners made of hard chilled metal.

Electric Equipment.—The British Westinghouse Electric and Manufacturing Company, Limited, Trafford Park, Manchester, send leaflets dealing with: Direct-current ammeters and volt meters with dial, sector and edgwise reading; oil-immersed control units for slip-ring type motors; and consumers' oil switch cubicle. The last-named are independent units for the control of single feeders, or on main switch panels for step-down transformers or large motors.

Decorticating Machinery.—Complete sets of machines for extracting, crushing, brushing and baling the fibre "sisal hemp" from the leaves of various plants is described in a catalogue from Messrs. Robey and Co., Limited, Lincoln, and 91 Queen Victoria-street, E.C., who also supply the engines, buildings, railways and wagons. There is an interesting description of the process by way of a preface to the catalogue. The special machines, and the method of working them, are clearly described and well illustrated.

Conveyors.—"Apron" conveyors are a series of tables, sometimes with box sides, running on chains and wheels, and carrying a continuous stream of coal, parcels, or other material, either on the level or on grades. The tables are lapped at the ends to make them flexible, and they are good containers for all but very small matter. They are well illustrated and explained in a catalogue issued by the Jeffrey Manufacturing Company, Ohio, U.S.A., who make them in a great variety of sizes and adaptations.

Expanded Metal.—Sheets of metal slit and drawn open to a kind of basket or net mesh have for many years been a standard manufacture. A booklet of 100 pages issued by the Expanded Metal Company, Limited, York, Mansion, York-street, S.W. 1, explains and illustrates the application of the metal mesh in building. It is used as a lathing for plaster work, and is embedded in plaster, mortar, or concrete, in making walls, ceilings, casings, floorings and frame buildings. The metal is made in several weights and meshes, from 2½ lb. to 5 lb. per square yard. Engineers and architects will find the handbook of real use.

Woodworking Machinery.—British-made woodworking machinery is well represented in a new catalogue issued by Messrs. Thomas Robinson and Son, Limited, Rochdale. Saws take a large space in such machinery on account of the many different forms of machine necessary to deal with logs, planks, &c., in cross and long cut. Planing, moulding, tenoning, and mortising machines are made in many forms of great power and precise adjustment. A sand-papering machine is made in four sizes of one type, for exact work. There are five lathes, and also a set of headstocks sold by themselves or with a countershaft. A number of special machines are made for railway plant work, including a sleeper adzing and boring plant on a two-bogie railway wagon, with engine and boiler and tool grinding machine complete.

Indian Trade.—Messrs. Turner, Hoare and Co., engineers and contractors, Bombay, who represent a number of large British engineering firms, send a stimulating pamphlet on future trade with India. Several tables of trade statistics up to 1914, are given, which show the preponderating hold which British machinery had in the Indian market. At the same time German and other metal manufactures were making substantial openings. We are grateful for these "blue book" figures in handy form, but we should be glad if British agents in India would give us the advantage of their detailed knowledge as to the particular classes of metal wares in which foreigners make headway against us. Even if a little frank comment or criticism were added, we feel sure it would be welcomed in home engineering circles. The best friend is he who tells us our faults.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

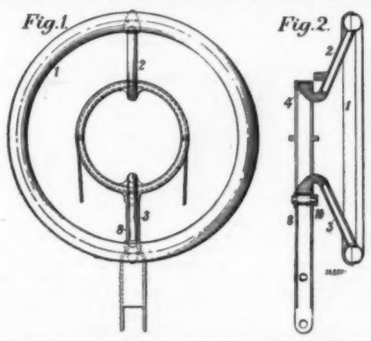
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

AERONAUTICS.

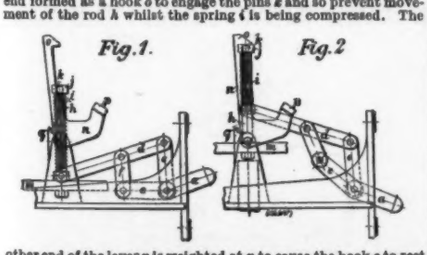
126,858. The Blackburn Aeroplane and Motor Company, Limited, Leeds, and H. Booth, Roundhay, Leeds. Aircraft Controlling Devices. (2 *Figs.*) July 10, 1918.—In hand-wheel control mechanism of aircraft, the wheel has only two spokes or arms 2, 3, connecting the annulus 1 of the wheel to an open annular boss 4, the two spokes being preferably in the same diametrical line and preferably arranged so that they shall be vertical and vary according to the movement given to the hand wheel some annular distance upon either side of such a vertical line, so that the pilot can have a clear view through the wheel and its boss, only obstructed by the approximately



vertical spokes and the annulus of the boss, and such a practically unobstructed view through the wheel is advantageous in many circumstances, as will be well understood. The invention moreover, provides a practical means for overcoming any objectionable resistance due to friction of the annular boss of the wheel in its carrying parts, consisting in providing a freely revoluble roller 10 carried by or from the control lever 8 in such a position as to support the lower part of the periphery of the annular boss 4 of the control wheel, which roller receives the pressure of the control wheel boss, and thus provides a very convenient and effective anti-friction device. (*Accepted May* 26, 1919.)

ELECTRICAL APPARATUS.

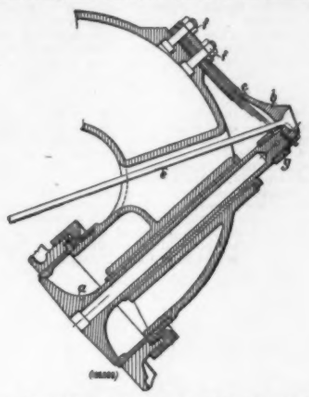
126,847. Ferguson, Pailin and Co., Limited, Manchester, S. Ferguson, Manchester, and G. Pailin, Manchester. Electrical Switches. (3 *Figs.*) June 20, 1918.—The invention relates to the type of switch apparatus wherein the first part of the closing movement effects the compression of a spring to a predetermined extent, when such spring is released and gives a rapid switch closing movement. The operating lever *a* is rigid with the arm *c* and operates the arm *d* which pivots about the end of the link *e* through the link *f*. One end of the arm *d* is pivotally attached to a collar free to slide on the rod *h* against the pressure of a coil spring *i*. The upper end of the rod *h* has secured thereon a collar *f* with projecting pins *k* at opposite sides. The rod *h* is secured to the bar *m*. A bell crank lever *n* has one end formed as a hook *o* to engage the pins *k* and so prevent movement of the rod *h* whilst the spring *i* is being compressed. The



other end of the lever *n* is weighted at *p* to cause the hook *o* to rest normally in the path of the pins *k*. A stop *q* limits the movement of the lever *n* from its normal position. In operation, the operating lever *a* is moved towards the position shown in Fig. 2, during which the switch bar *m* is raised into a position in which the switch contacts are almost, but not quite, making contact. The movement of the bar *m* is then arrested by the hook *o* engaging the pins *k*, after which the spring *i* is compressed until the mechanism reaches the position shown in Fig. 2. Further movement of the operating lever *a* causes the arm *d* to engage the end *p* of the bell crank lever *n*, which results in said lever being turned about its pivot and the hook *o* clearing the pins *k*. Immediately the spring *i* expands, forces up the rod *h* and closes the switch by raising the bar *m* to its final position. (*Accepted May* 28, 1919.)

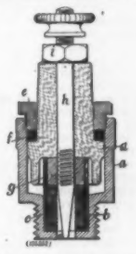
GAS ENGINES, PRODUCERS, HOLDERS, &c.

126,699. Peter Brotherhood, Limited, Peterborough, C. W. Bryant, Peterborough, and G. F. Jones, Peterborough. Internal-Combustion Engines. (3 *Figs.*) February 16, 1917.—The present invention relates to valve-operating gear for internal-combustion engines. The invention consists in operating the valve by means of a tension rod having a head of spherical form engaging with a spring rocker, the valve being normally kept on its seat by a leaf spring. The inlet valve *a* is normally held on its seat by a leaf spring *c* of cantilever form. The end of the rocker *b* is drilled and formed to engage with the hemispherical end of a tension rod *e* by which the valve is worked. This tension rod passes through a hollow in the induction pipe,



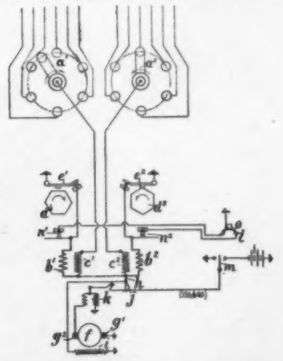
the section of the pipe being streamlined at the point where it passes through the pipe to avoid loss. The rocker *b* and spring *c* are held by the same bolts *f*, *f*, the free ends of the spring being forked to engage with the projecting parts of the valve cap *g*. The spring effort can be adjusted either by adding leaves to the spring or by raising the spring on its carrying facing. (*Accepted May* 28, 1919.)

126,852. B. Hopps, Rugby, A. M. Lodge, Rugby, and The Lodge Sparking Plug Company, Limited, Rugby. Sparking Plugs. (2 *Figs.*) June 28, 1918.—The metal body *a* is formed internally at its inner end with a cylindrical portion of smaller diameter than the outer end. Into the inner end is inserted a bush *b* constructed from mica washers. This bush is supported by a shoulder at the inner end of the body and is surrounded by a wrapping *c* of mica, which lies between the outer surface of the bush and the inside of the body. Into the upper end of the body is inserted a ceramic insulator *d* which is held in position by a gland *e* or by the turning over of the body on to a shoulder on the insulator, and packing *f* is provided to produce the required gastight joint. Betweenthe underside of the ceramic insulator and the upper side of the mica bush is a



metal collar *g*, which is held in position, and in turn serves to hold in position, the mica bush, under the pressure of the ceramic insulator. The collar is also enclosed by the mica wrapping. An aperture in the collar is formed in line with an axial aperture in the ceramic insulator and the collar aperture is screwed to receive a screwed portion of the central electrode *h*. A collar *i* formed integrally with the outer end of the electrode bears on the outer end of the ceramic insulator and produces a gastight joint around the outer end of the electrode. The central aperture in the mica bush is of larger diameter than that part of the electrode and has its inner surface exposed to the gases in the engine cylinder. A spark gap is provided between the inner extremity of the central electrode and the outer body. (*Accepted* May 28, 1919.

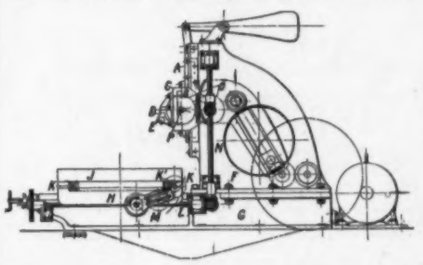
126,840. A. H. Midgley, Acton, and C. A. Vandervell and Co., Limited, Acton. Ignition Systems. (1 *Fig.*) June 13, 1918.—This invention relates to an ignition system for internal-combustion engines of the kind in which a dynamo arranged in parallel with a battery of accumulators is connected



to the ignition coil or coils. According to the invention, the connecting wire between the dynamo and the ignition coil is connected to the battery by means of a two-way switch, which in one position connects both the dynamo and the ignition coil or coils to the battery, and in the other position disconnects the battery and short-circuits both the dynamo and the ignition coil or coils. The short-circuiting connection effected by the switch also effects the short-circuit of the shunt winding of the dynamo when the automatic cut-out is open. a^1, a^2 are two distributors associated with two banks of cylinders, b^1, c^1, the primary and secondary coil of the ignition coil, and d^1, e^1, the cam and earthed make-and-break of the circuit breaker associated with one bank of cylinders, and b^2, c^2, the primary and secondary coil of the ignition coil, and d^2, e^2, the cam and earthed make-and-break of the circuit breaker associated with the other bank of cylinders. The dynamo *f*, one brush *g*1 of which is earthed, whilst its other brush *g*2 is connected to the ignition system by a connecting wire *h*, is provided with a shunt winding *i*, one end of which is earthed, whilst its other end is connected to the point of connection *j* between the dynamo and the ignition system, the automatic cut-out *k*, which is employed for disconnecting the dynamo from the battery when the speed of the dynamo falls below its normal charging speed, being inserted between the brush *g*2 and the point of connection *j*. The connecting wire *h* between the dynamo and the ignition coils is connected to the earthed battery *l* by means of a two-way switch *m*, which in one position connects both the dynamo and the ignition coils to the battery, and in the other position disconnects the battery and short-circuits both the dynamo and the ignition coils through earth. Each of the ignition coils is provided with a trembler n^1, n^2, which are controlled by the closing of an earthed switch *o*, and are operative when the corresponding make-and-breaks e^1, e^2, are open. (*Accepted May* 28, 1919.)

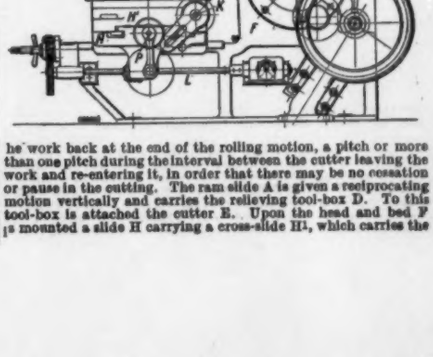
MACHINE AND OTHER TOOLS, SHAFTING, &c.

126,930. William Muir and Company, Limited, Manchester, J. H. Melloy, Manchester, and W. Owen, Stretford, Manchester. Gear Cutting and Slotting Machines. (3 *Figs.*) February 20, 1919.—This invention refers to improvements in machines for cutting teeth in spur and spiral gear, in which a generating cutter, having a reciprocating motion, is used. Each periodic dividing or indexing motion is performed instantly, by dropping the cutter back at the end of the rolling motion, a pitch or more than one pitch during the interval between the cutter leaving the work and re-entering it, in order that there may be no cessation or pause in the cutting. The cam slide A is given a reciprocating motion vertically and carries a cross-slide B, on the face of which is the saddle C, which carries the relieving tool-box D. To this tool is attached the cutter E. The head F carrying the reciprocating ram slide A is carried upon a bed G, upon which, on slide ways, is mounted a slide H carrying the circular worktable J. This table is adjustable towards the head F and is provided with a large and accurate worm wheel K for controlling and rotating the work blank or gear attached to the table. The automatic rotation of the work is under the control



of the ordinary feed motion and comes into operation when the tool is clear of the work at the top of the stroke. The feed motion is actuated from the shaft L, through to the change wheels M on to the worm shaft K1. Simultaneously the vertical feed shaft N actuates through gears O the shaft P, on which is mounted a scroll arm of a pitch or a multiple of the pitch of the gear being operated upon. The cam acting against a similar cam fixed in the saddle C and being prevented from rotating, moves the saddle C across, causing the pitch line of the cutter E to travel tangentially to, and at the same rate and in the same direction as, the pitch cylinder of the wheel being operated upon, thus establishing the necessary relative rolling motion between the rack formed cutter E and the work blank or gear being cut. Upon the completion of each revolution of the shaft P, and consequently the completion of one pitch or multiple thereof of the gear being cut, the saddle C carrying the tool-box and cutter E, under the influence of springs, drops instantly back a distance equal to the pitch of the cam, this distance corresponding to one pitch or more than one pitch of the gear, as may be required, and the movement being accomplished during the interval between the tool leaving the work and re-entering it. (*Accepted May* 28, 1919.)

126,931. William Muir and Co., Limited, Manchester, J. H. Melloy, Manchester, and W. Owen, Manchester. Gear Cutting and Slotting Machines. (3 *Figs.*) February 20, 1919.—This invention refers to improvements in machines for cutting teeth in spur and spiral gears, in which a generating cutter, having a reciprocating motion, is used. Each periodic dividing or indexing motion is performed instantly, by dropping

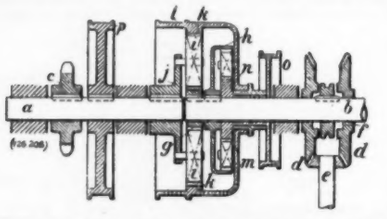


he work back at the end of the rolling motion, a pitch or more than one pitch during the interval between the cutter leaving the work and re-entering it, in order that there may be no cessation or pause in the cutting. The ram slide A is given a reciprocating motion vertically and carries the relieving tool-box D. To this tool-box is attached the cutter E. Upon the head and bed F is mounted a slide H carrying a cross-slide H1, which carries the

circular worktable J. This table is adjustable towards the head of the machine, and is provided with a large and accurate worm wheel for controlling and rotating the work blank J1 attached to the table. The automatic rotation of the work is under the control of the feed motion and comes into operation when the tool is clear of the work at the top of the stroke. The feed motion is actuated from the shaft L through gearing to the worm shaft K. On the shaft P is mounted the scroll cam of a pitch equal to the pitch or a multiple of the pitch of the gear being operated upon, and this cam, acting against a similar cam fixed in a bracket carried on the cross-slide H1, and prevented from rotating, moves the cross-slide and the work across. The motion thus imparted to the work acting in unison with the rotation of the work through change wheels in the driving gear, causes the pitch circle of the work to rotate along an imaginary plane described by the pitch line of the rack-formed cutter E, thus establishing the necessary rolling motion between the cutter E and the work blank J1 being cut. Upon the completion of each revolution of the shaft P, and consequently the completion of one pitch or multiple thereof of the gear being cut, the cross-slide H1, under the influence of the springs, drops instantly back a distance equal to the pitch of the cam, this movement being accomplished during the interval between the tool leaving the work and re-entering it. (*Accepted May* 28, 1919.)

MOTOR ROAD VEHICLES.

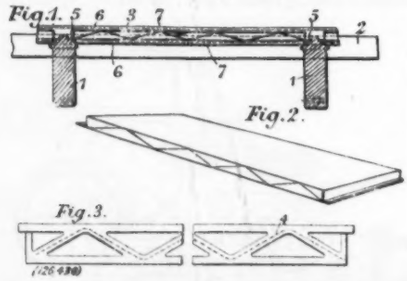
126,208. Sir A. G. H. W. Moore, London, and W. G. Wilson, Farningham. Mechanically-Propelled Vehicles. (2 *Figs.*) July 8, 1918.—This invention relates to heavy mechanically-propelled vehicles, and particularly those of the type fitted with ground chains. The invention comprises the combination of a pair of co-axial shafts which operate the ground chains, an intermediate co-axial driving shaft, and a compound epicyclic mechanism arranged between the intermediate shaft and each of the first-mentioned shafts. Each ground chain has connected to it through suitable gearing a shaft *a* (termed a chain shaft), which is connected to an intermediate shaft *b* through compound epicyclic mechanism. The three shafts are in alignment, the intermediate shaft being situated between the other two. In the drawing only one of the shafts *a* is shown. The chain shaft *a* communicates its motion to the chain mechanism through a sprocket *c*. Motion is imparted to the intermediate shaft *b* through bevel gears *d*, from a shaft *e* actuated by the engine. Two bevel wheels are provided on the intermediate shaft, and each is arranged to gear with a single bevel pinion on the engine shaft, one or the other of the bevel wheels being clutched to its shaft by a clutch member *f* according to the required



direction of rotation. Each end of the intermediate shaft *b* is fitted with a compound epicyclic mechanism. Such mechanism comprises a sun pinion *g* of one train and an annulus *h* of another train, both secured to the shaft *b*. The sun pinion *g* gears with planet pinions *i* on a carrier *j*, secured to the adjacent chain shaft *a*. These planet pinions gear with an annulus *k* mounted in a rotatable case *l*, which also serves as a brake drum, and as the carrier for planet pinions *m* of the other gear train. A sun pinion *n* gearing with the second planet pinions *m* is freely mounted on the intermediate shaft and provided with a brake drum *o*. When the annulus *k* of the first train is locked by its brake, the sun pinion *n* of the second train is free. The first train only is then operative. On liberating the annulus *k* and locking the second sun pinion *n* by means of the brake drum *o*, both trains are brought into action. By such a mechanism two speed ratios can be obtained between the shafts *a* and *b*. Also the two chain shafts *a* can be driven with equal or unequal speeds. Consequently for forward or rearward motion in a straight course the two ground chains can be driven equally at either of two speeds. Whilst for manœuvring the ground chains can be driven at unequal speeds. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

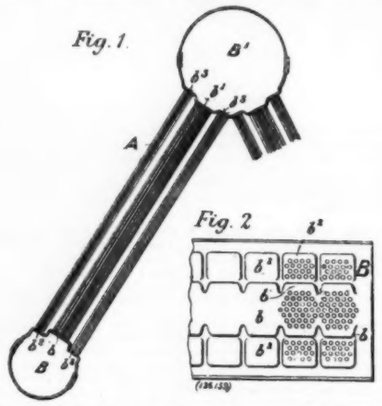
126,430. J. C. Grant, London. Steamships. (5 *Figs.*) May 1, 1918.—The invention relates to the construction of ocean-going steamships built of ferro-concrete or ferro-cement transverse and longitudinal members, and has for its object to form a cellular structure in which the use of shuttering is rendered unnecessary. The invention consists in building up a ferro-concrete or ferro-cement structure of transverse members and longitudinal members forming a framework, the spaces of which are filled by hollow ferro-concrete or ferro-cement panels, and in providing on the outside or inside or both of the hollow panels reinforcement



covered with a layer of cement or concrete. At suitable intervals along the length of the ship transverse members 1 of ferro-concrete or ferro-cement are formed. These are recessed at vertical intervals to receive longitudinal members 2, also of ferro-concrete. In the rectangular spaces thus formed are placed panels 3 which are hollow structures indicated more in detail in Figs. 2 and 3. These hollow panels are moulded of two walls connected by transverse members of zig-zag form, with or without reinforcement 4. These panels 3 are connected to the framing by liquid cement, and are held in place by wires projecting from the frame and bent over the flanges 5. The reinforcement 6, consisting of wire netting or expanded metal, is then placed on the inside or outside or both of the panels 3, a final layer of concrete 7 being then applied. (*Sealed.*)

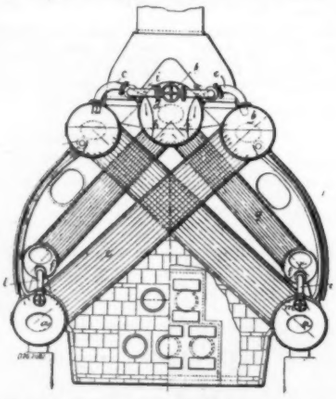
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

126,159. V. Smith, Wolverhampton. Water-Tube Boilers. (3 *Figs.*) May 13, 1918.—This invention relates to water-tube boilers of the inverted V-type, in which the drums with which the inclined water-tubes communicate have each three rows of pockets arranged lengthwise of the drum, which pockets provide flat surfaces for the reception of tube ends. The pockets are so formed that considerable spaces occur between groups of tubes, and the main feature of this invention consists in fixing to the portions of the drums which lie between the groups of tubes of the middle row of pockets a number of intermediate or auxiliary tubes. Two oppositely-inclined batteries A of water-tubes communicate with lower drums B, respectively, and both of them communicate at their upper ends with a single drum B1. Middle pockets, such as *b*, *b*1, and pockets which are stepped back therefrom, such as *b*2, *b*3, are formed in the metal of the drums, through flat surfaces of which holes are formed for the reception of ends of water-tubes of the batteries A. In Fig. 2, two groups of water-tubes are shown as arranged across the upper side of the drum B. Through the flat surface of each pocket *b*, and also through the flat surface



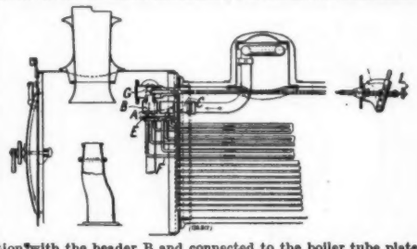
of each pocket *b*2, there are holes for a number of tubes of each set which are spaced apart lengthwise of the drum, and a number of tubes which are spaced apart transversely of the drum. There are spaces *b*4 left between the pockets *b*2, and therefore there is a substantial space between the groups of tubes which communicate with the drum through the holes of the pockets *b*2; but there is no corresponding space left between the groups of tubes which communicate with the drum through the holes of the pockets *b*, as the space between the two groups which would correspond with the space between the groups which communicate through the holes of the pockets *b*2, has intermediate or auxiliary water-tubes *a*1 therein, and to facilitate the connection of these tubes with the drum the middle portions of the flat surfaces of the pockets *b* are carried through into one another, as indicated. These tubes *a*1 consequently prevent the heated gases from passing through between the groups of tubes which are fixed within the holes of the pockets *b* in the free manner in which they pass through between groups of tubes which are fixed within holes of the pockets *b*2, and consequently take up much heat from the gases which would otherwise pass away to the chimney. (*Sealed.*)

126,168. R. and W. Hawthorn Leslie and Co., Limited, Newcastle-on-Tyne, and R. B. Armstrong, Newcastle-on-Tyne. Water-Tube Steam Boilers. (2 *Figs.*) May 15 1918.—This invention has reference to water-tube boilers of the type comprising upper and lower vessels connected by generating tubes and provided with steam drums subdivided by transverse partitions, and with superheating tubes which connect the several compartments thereof to a water drum. According to the present invention, such subdivided steam drums are provided with valved connections whereby the steam spaces of the compart-



ments can be placed in direct communication, by which arrangement all the superheating tubes can be made to serve as generating tubes and the saturated steam generated passed from all the compartments to the ordinary steam outlet. There are two lower water drums *a* with a furnace between them and two upper steam and water drums *b* parallel thereto and connected by steam pipes *c* to a common steam drum *d* between them. Each lower drum *a* is connected to the opposite upper drum *b* by transverse rows of inclined generating tubes *e* crossing beneath the steam drum *d*. Above each lower water drum *a* is a smaller drum *f* with transverse rows of inclined superheating tubes *g* extending therefrom to the lower side of the steam drum *d*, these tubes lying over the one set of transverse rows of tubes and crossing the other set. The steam drum is divided by two or more longitudinal partitions *h* into three or more compartments, each partition being arranged to cut off the upper ends of some of the corresponding set of superheating tubes *g* from the others, and to cut off the steam pipe connection *c* with the corresponding steam and water drum *b* from the middle compartment. The two steam pipe connections *c* are provided with a valved connection *i*, said connection being fitted with a stop valve *k* whereby the steam spaces of the compartments can be placed in direct communication. The small drums *f* are respectively connected by pipes *l* at the front ends to the water drums *a* beneath them through stop valves *m*. When raising steam the stop valves *k* and *m* are open and the superheating tubes *g* then act as additional generating tubes; when it is desired to superheat the steam the stop valves *k* and *m* are closed, saturated steam then passing from each outer compartment of the steam drum through those of the superheating tubes *g* in communication with it and returning from the small drum *f* below through the remainder of that set of superheating tubes to the middle compartment of the steam drum. (*Sealed.*)

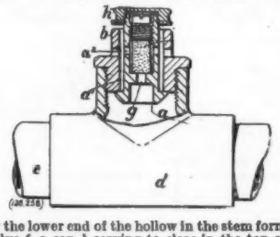
126,817. Babcock and Wilcox, Limited, London, J. Kemnal, London, and J. Henry, London. Steam Superheaters. (5 *Figs.*) May 22, 1918.—According to the invention, the regulator provided is of the piston valve type, and is adapted to control the outlet side of the superheater. A is the main saturated steam inlet header and B the main superheated steam outlet header. Expanded into the headers A, B, are nipples also expanded into the upper halves of receivers E, into the lower halves of which are expanded the superheater tubes F, each tube being led from one compartment of the relative receiver E into and through one of the fire tubes of the boiler, and thence back to the other compartment of the receiver. G is the regulator, which serves the entire installation, and which is in communica-



tion with the header B and connected to the boiler tube plate. Movable within the casing of the regulator is a piston valve fitted to a hollow valve spindle and controllable by operation of the lever H2. The regulator valve, when open, permits the passage of superheated steam from the header B to the engine cylinders. When closed, the regulator permits the superheated steam to circulate back into the boiler without being throttled. The tubular valve spindle is formed adjacent the valve with a slot or port controllable by adjustment of an internal spindle fitted with the hand wheel L. The slot or port permits passage of saturated steam into and through the interior of the tubular valve spindle to mix with the superheated steam, and thus to regulate the degree of superheat. (*Accepted May* 28, 1919.)

MISCELLANEOUS.

126,258. F. Taylor, Radcliffe, and H. G. Taylor, Radcliffe. Low-Pressure Steam Heating Apparatus. (3 *Figs.*) April 29, 1918.—This invention refers to a combined automatic mechanical and thermally controlled vacuum valve for use in steam heating apparatus. According to the present invention, the improved automatic mechanical valve consists of an ordinary (mushroom) valve adapted to be fitted in the upper part of a steam pipe and to fall from its seating by gravity, or under the pressure of the outside air, when unsupported by steam in the pipe, and to close such seating under the pressure of the steam. *a* is the valve, the stem part *a*1 of which extends upward through the tubular casing *b*, and at its upper end is supported by a flange upon the top edge of the casing *b*, the position of the flange and the length of the valve stem being such as to cause the top face of the valve, when the valve is open, to lie a slight distance below the end of the casing *b*. The casing *b* screws into the upright branch of the tee coupling *d* fitted in the length of the steam pipes *e*. The valve stem is hollow and the heat controlled valve is located therein. Said valve consists of a cylindrical body *f* of expansive material, arranged within the valve stem *a*1 and connected to and adjustably supported by a boss screwing into the upper part of the valve stem. In the valve, and opening into the hollow of the stem part is a through hole *g*, and the shoulder



formed by the lower end of the hollow in the stem forms a seating for the valve *f*, a cap *h* serving to close in the top of the valve stem. When cold, the valve is at its shortest length and lies clear of the hole *g*, but when heated, the valve elongates and closes the hole *g*. In the wall of the valve stem are holes *a*2, and in the wall of the casing *b* are holes *b*1. The improved valve operates as follows: Steam being present in the steam pipes, it serves to raise the valve and hold it firmly against the lower end of the casing *b*, thereby preventing the escape of steam, whilst also preventing the ingress of air. As soon, however, as the steam fails, which in low-pressure heating apparatus is liable to happen when the boiler fire is cooled down by fresh fuel, or when the fire burns very low, the valve *a* instantly drops and thereby prevents the formation of a vacuum and effectually prevents the water in the boiler flowing into the steam pipe. Upon the steam again flowing through the pipes and its pressure rising, the valve *a* closes, but not until the bulk of the air previously admitted has escaped, the steam pressure usually rising slowly, driving the air before it, and then closing the valve. If the steam pressure rises quickly some of the air would be trapped, but the heat-controlled valve does not instantly open, but opens slowly, and usually some seconds after the valve *a*, and also closes slowly, thereby giving time for the air in the pipes to escape. (*Sealed.*)